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Satake et al.

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(45) **Date of Patent: Oct. 8, 2002**

(54) **ROTARY SHAKING SEPARATOR**

(75) Inventors: **Satoru Satake, deceased**, late of Hiroshima, by Toshiko Satake, legal representative; **Akira Fukuhara**, Tokyo; **Kiminori Kono**, Tokyo; **Masahide Houri**, Tokyo; **Shigeki Kinoshita**, Tokyo; **Masashi Kageyama**, Tokyo; **Chozaburo Ikuta**, Tokyo; **Haruyoshi Yamaguchi**, Tokyo, all of (JP)

(73) Assignee: **Satake Corporation**, Tokyo (JP)

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(22) Filed: **Dec. 5, 2000**

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(30) **Foreign Application Priority Data**

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Nov. 8, 2000 (JP) 2000-339798

(51) **Int. Cl.**[7] **B07B 13/00**

(52) **U.S. Cl.** **209/480**; 209/365.4; 209/505; 209/691

(58) **Field of Search** 209/309, 311, 209/315, 325, 326, 364, 365.1, 365.4, 369, 479, 480, 481, 505, 691, 694

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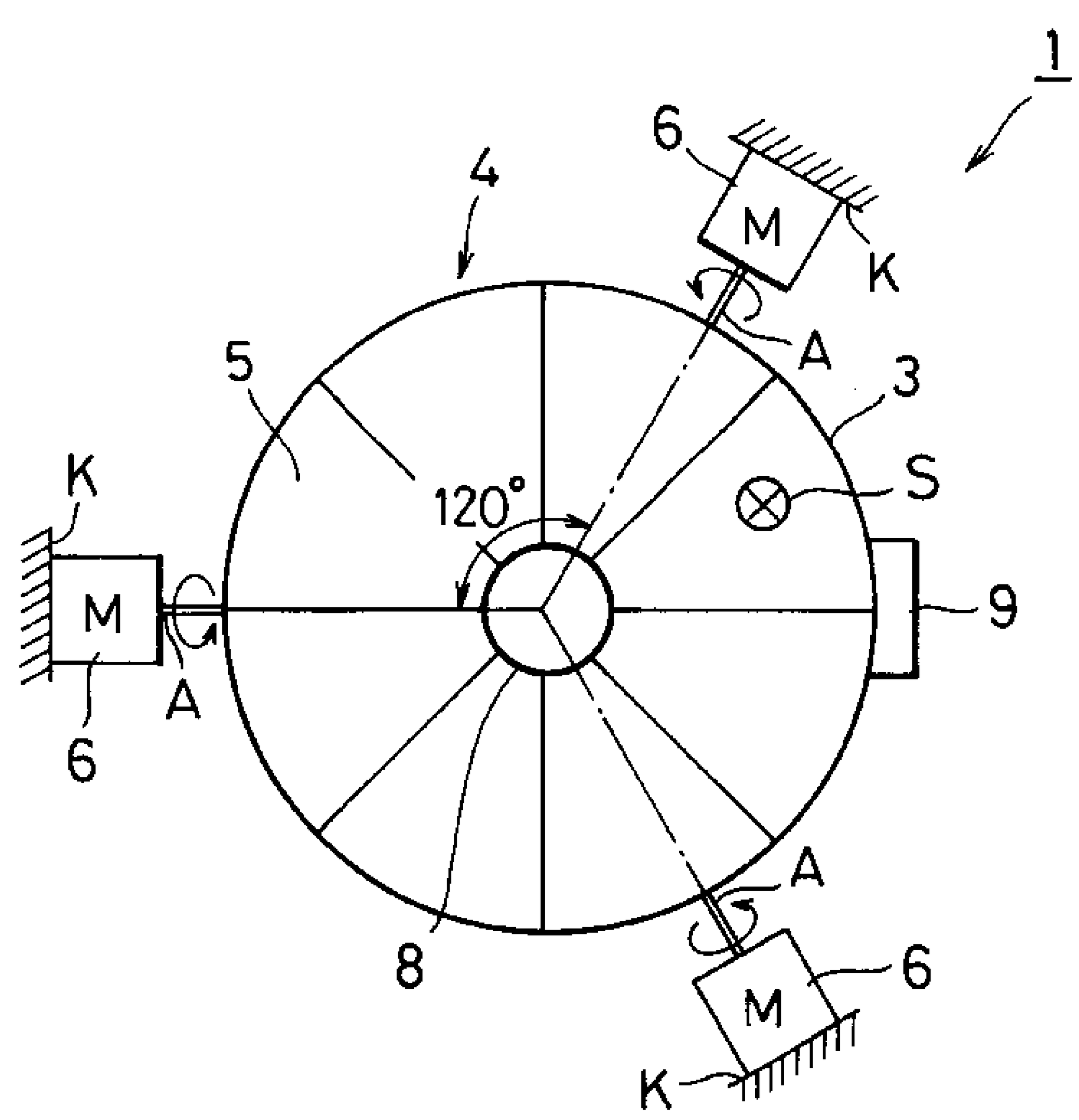
Primary Examiner—Tuan N. Nguyen
(74) *Attorney, Agent, or Firm*—Pillsbury Winthrop LLP

(57) **ABSTRACT**

A rotary shaking separator for separating unhulled rice and unpolished rice from each other includes at least one separating vessel and a plurality of drives located at even intervals on the peripheral edge of the separating vessel, the plurality of drives being actuated to bring the whole of the separating vessel into a rotationally shaking motion.

12 Claims, 16 Drawing Sheets



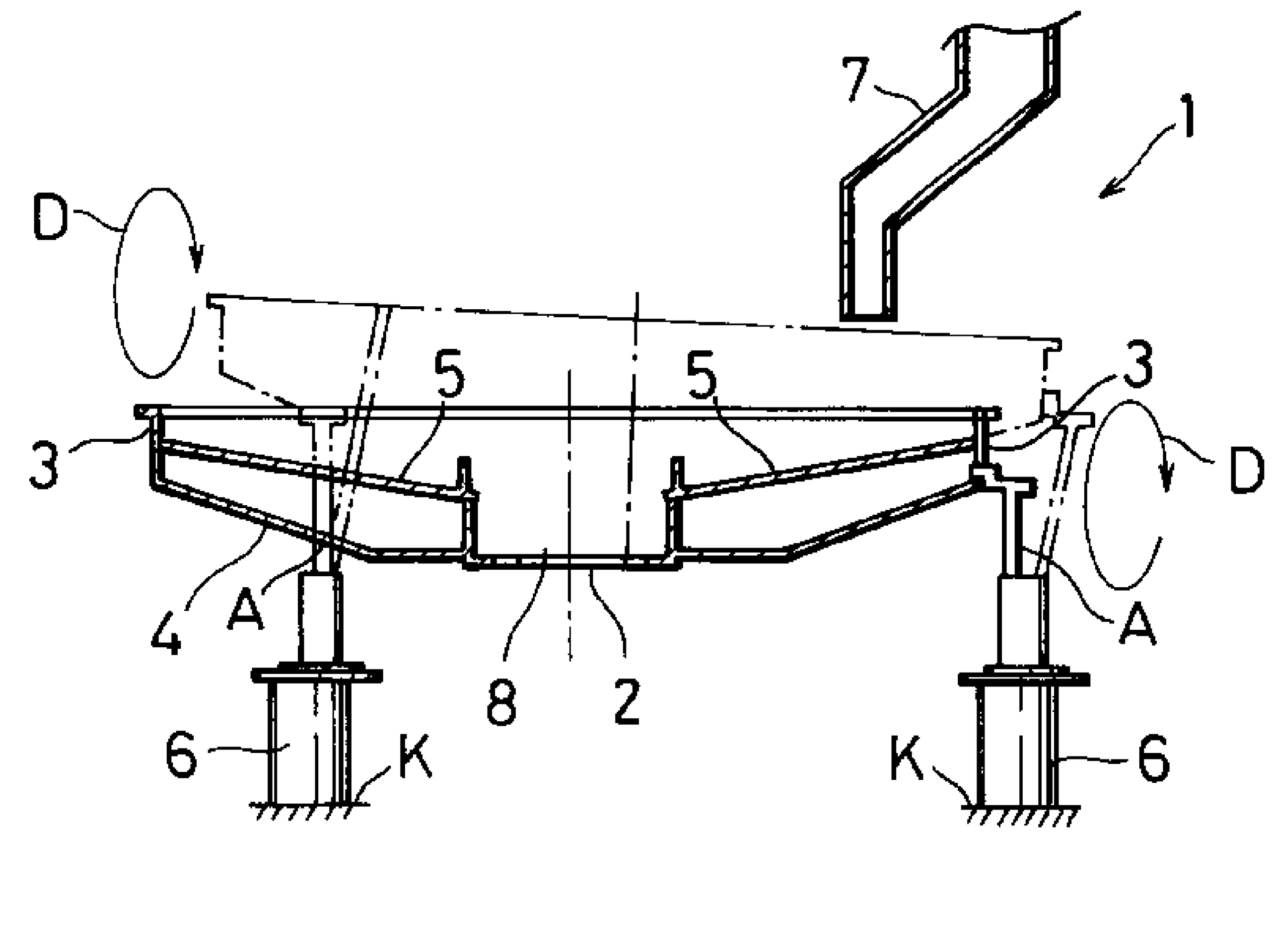


FIG. 1

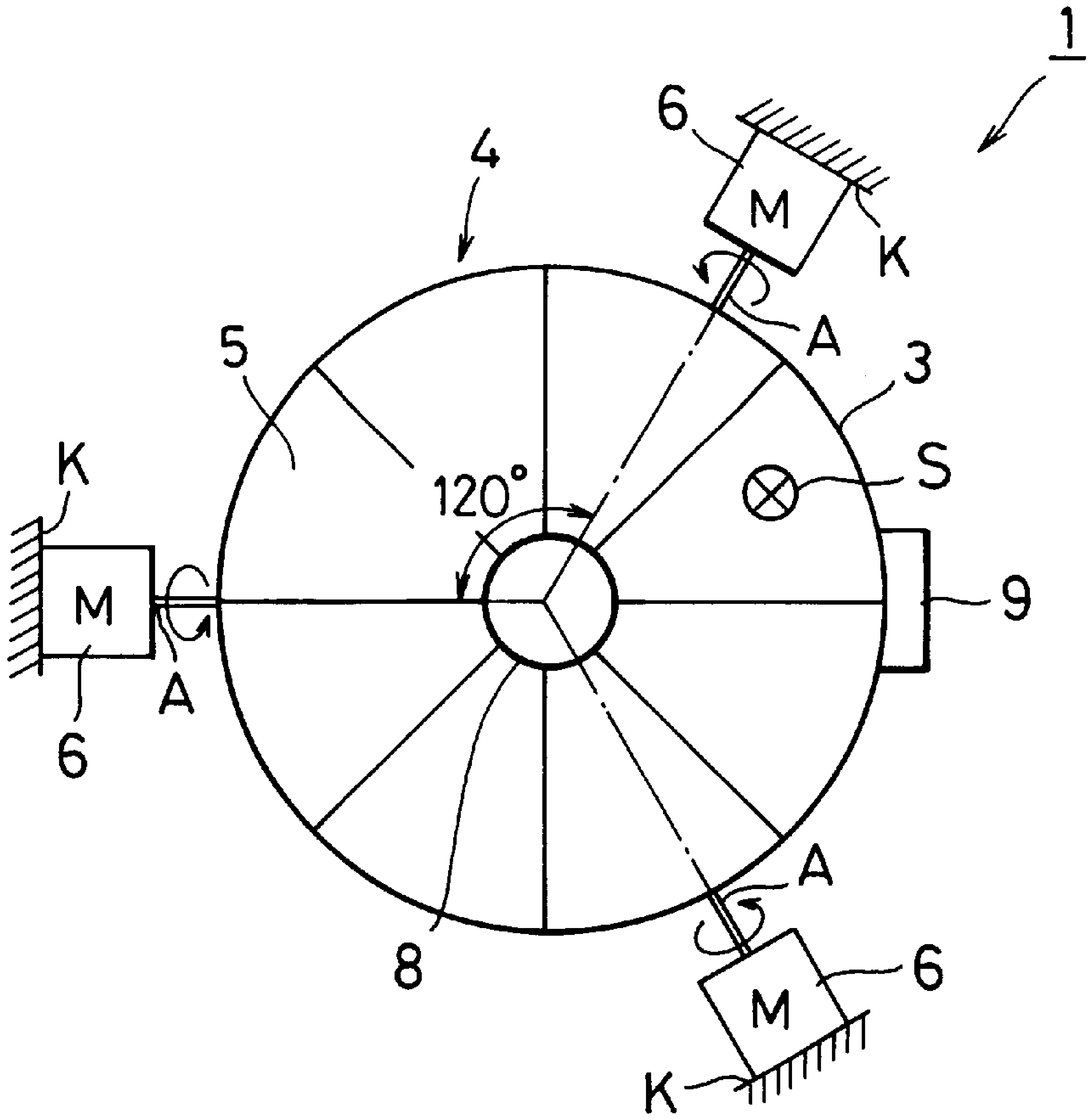


FIG. 2

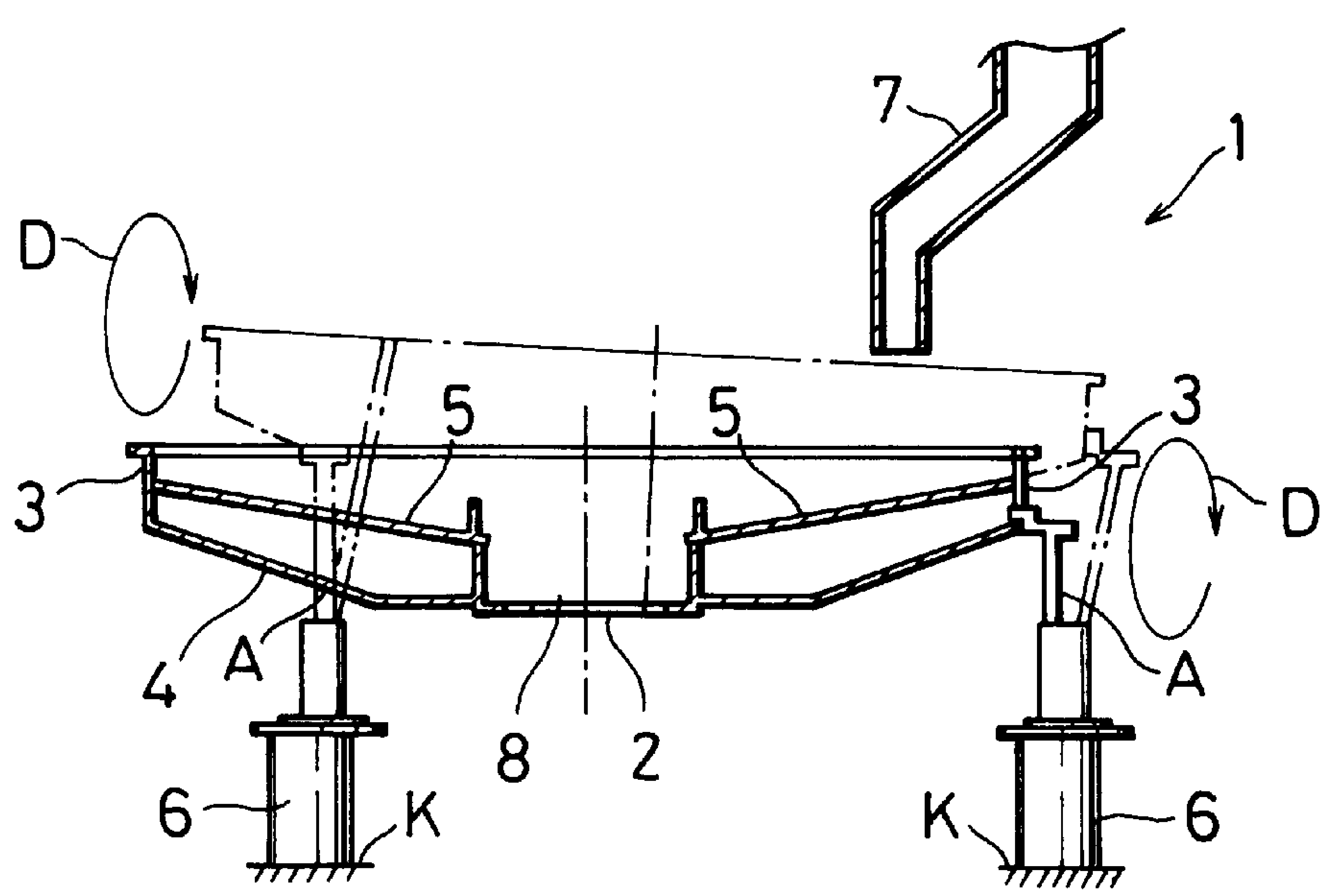


FIG. 3

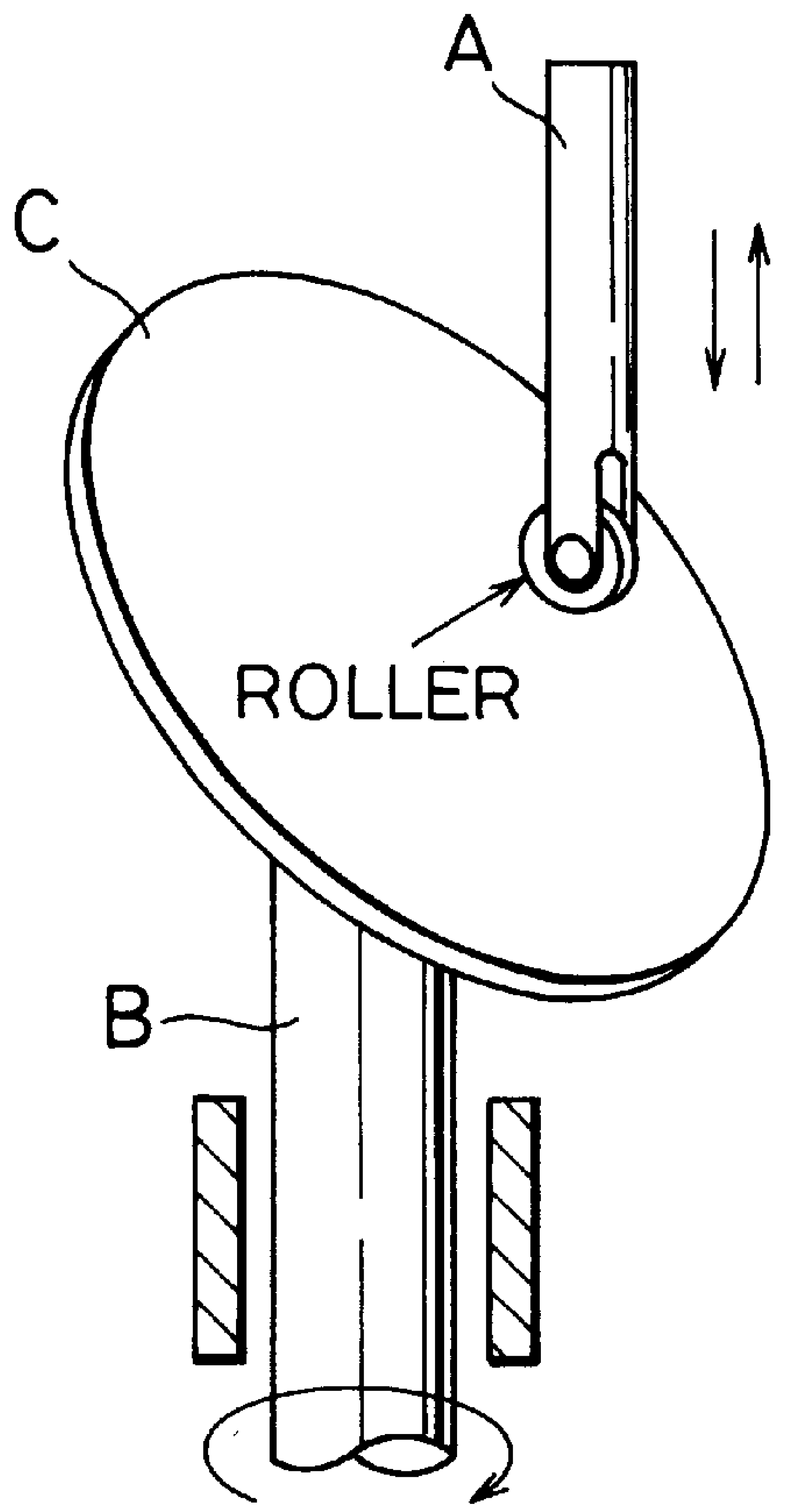


FIG. 5

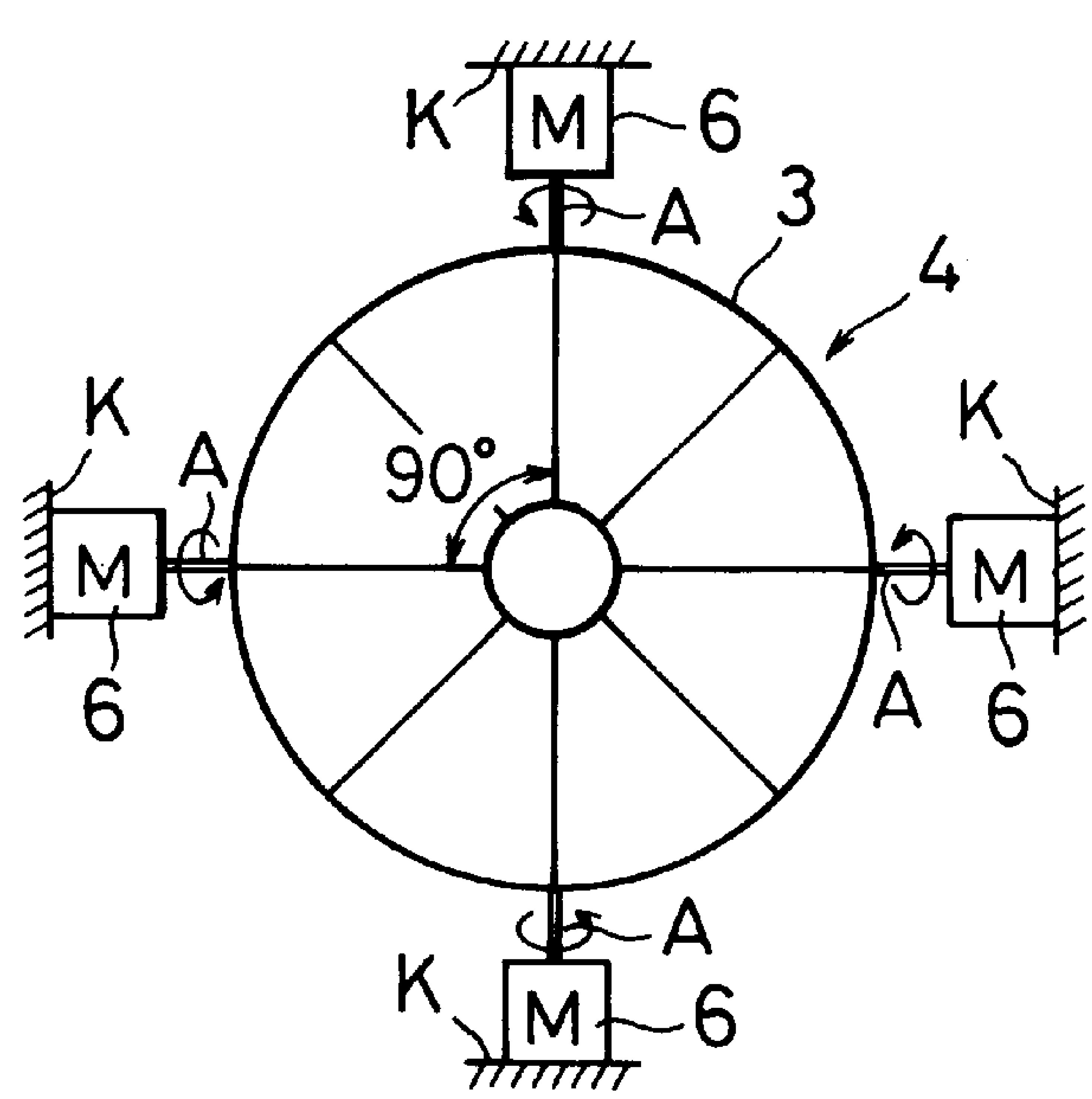


FIG. 4

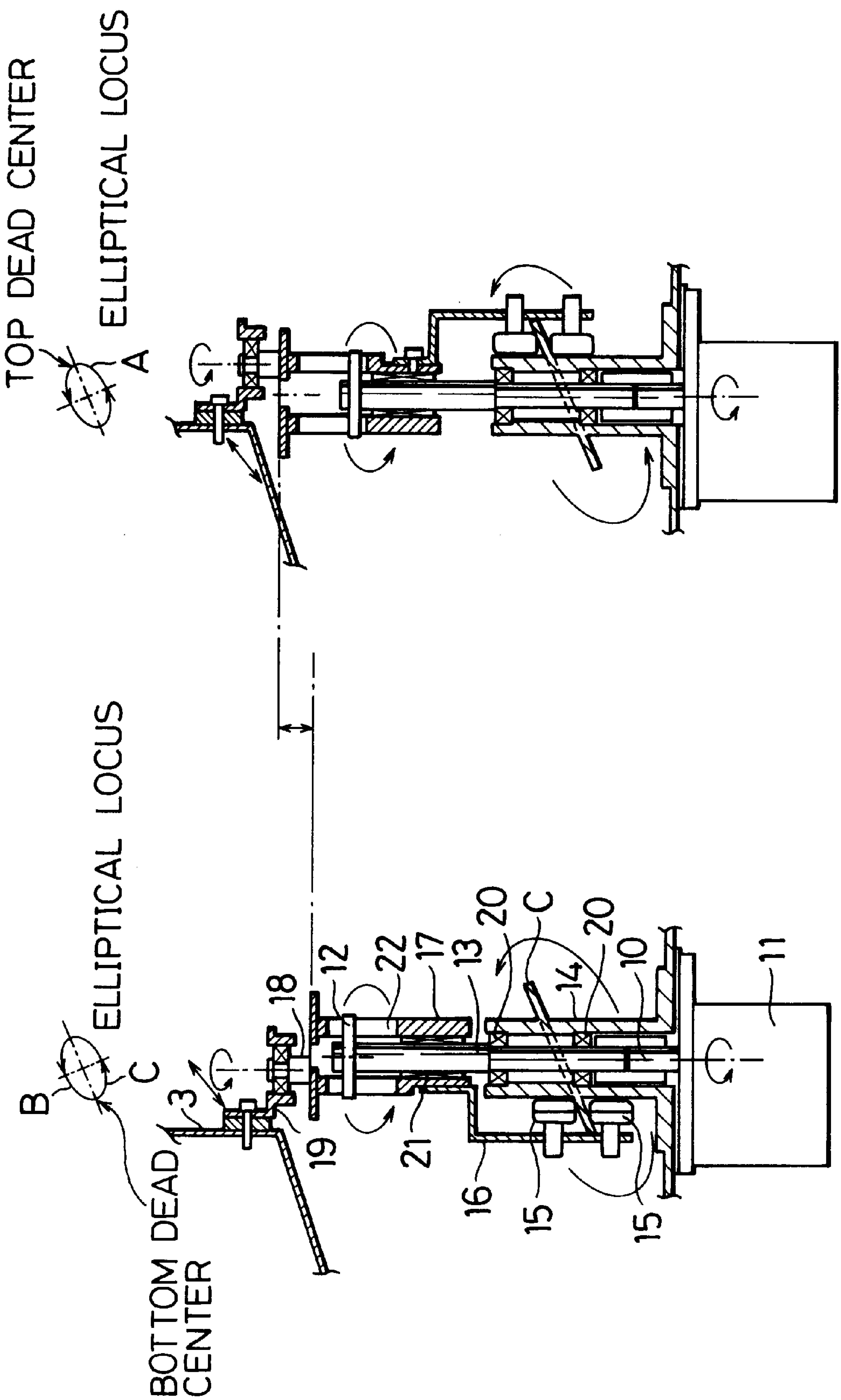
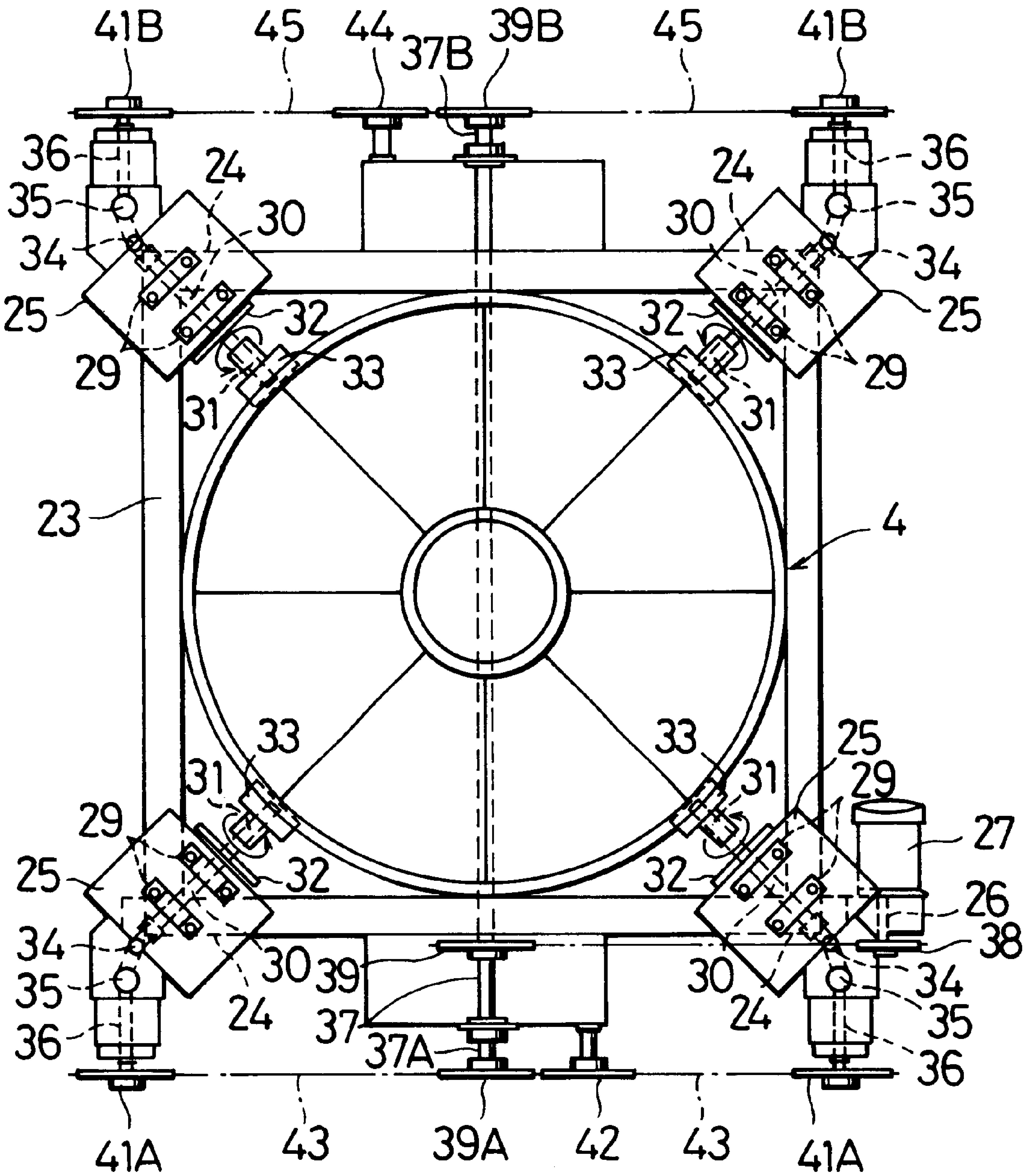

TOP DEAD CENTER
ELLIPTICAL LOCUS
A
ELLIPTICAL LOCUS
B
C
BOTTOM DEAD CENTER
3
19
18
12
22
17
13
20
C
20
14
10
11
21
16
15
15

FIG. 6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37B
39B
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41B
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24
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25
32
29
33
31
23
4
33
31
25
29
27
26
38
32
30
39
37
37A
24
34
35
36
41A
43
39A
42
43
41A

FIG. 7

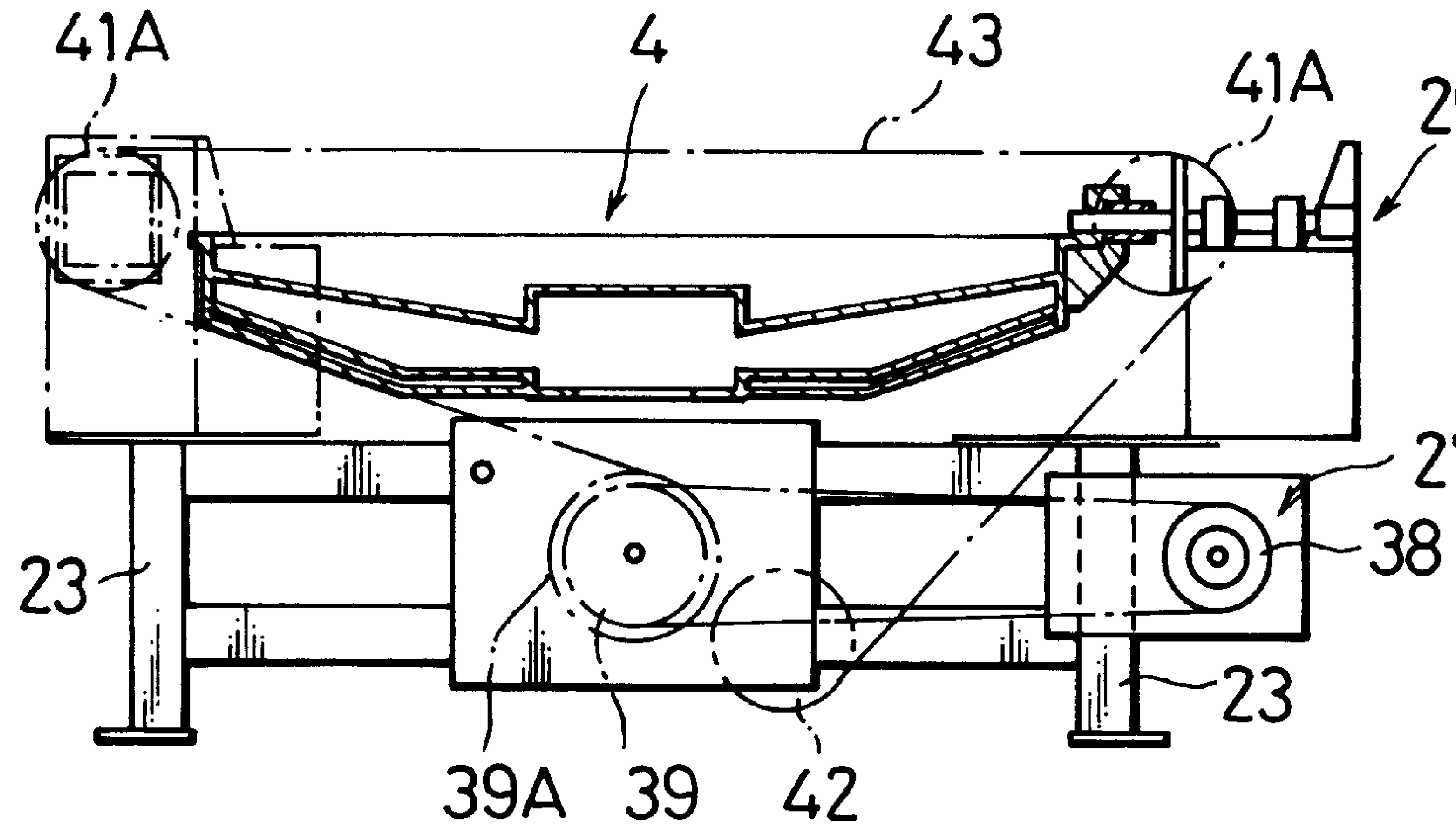


FIG. 8

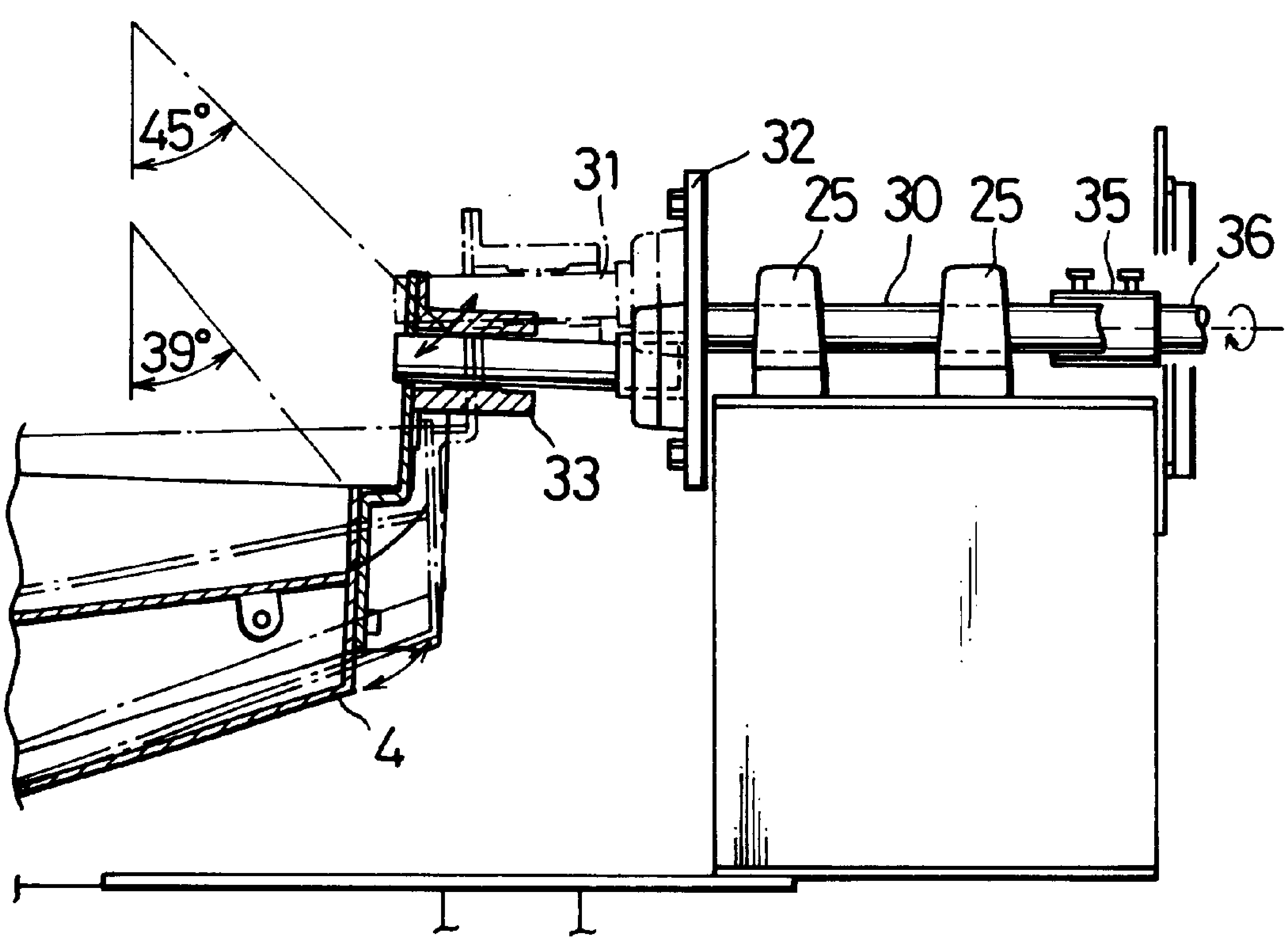


FIG. 9

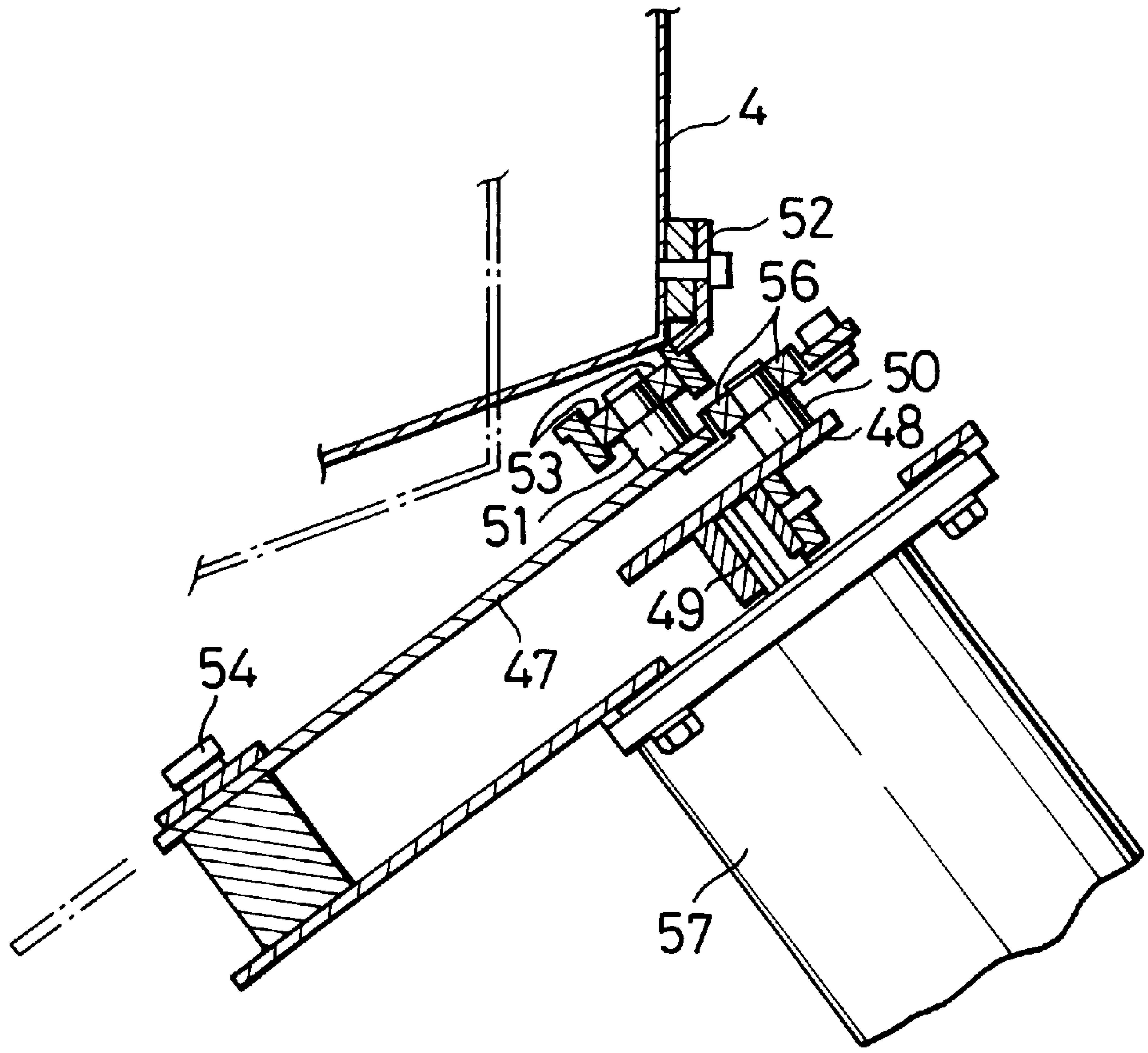


FIG. 10

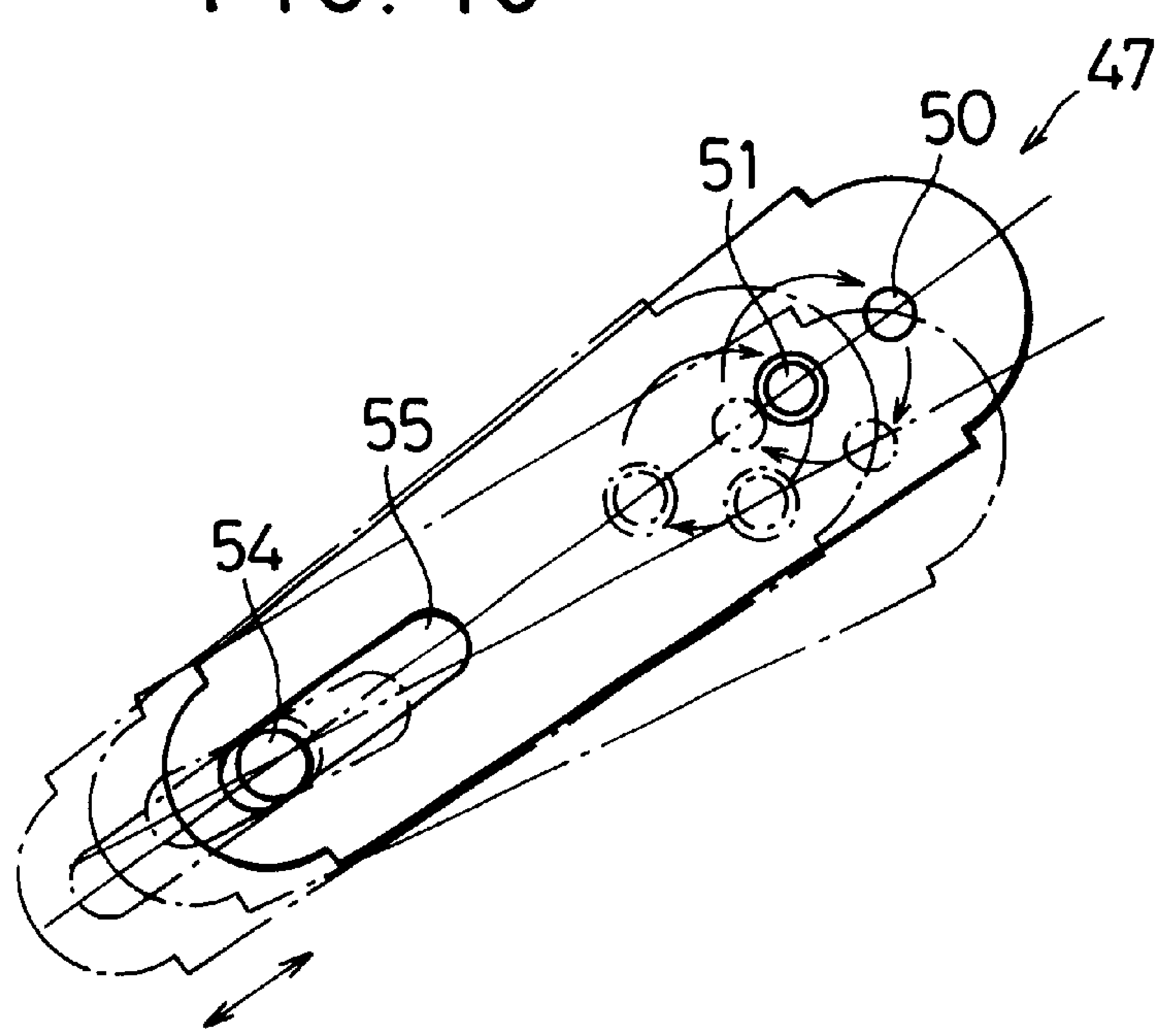


FIG. 11

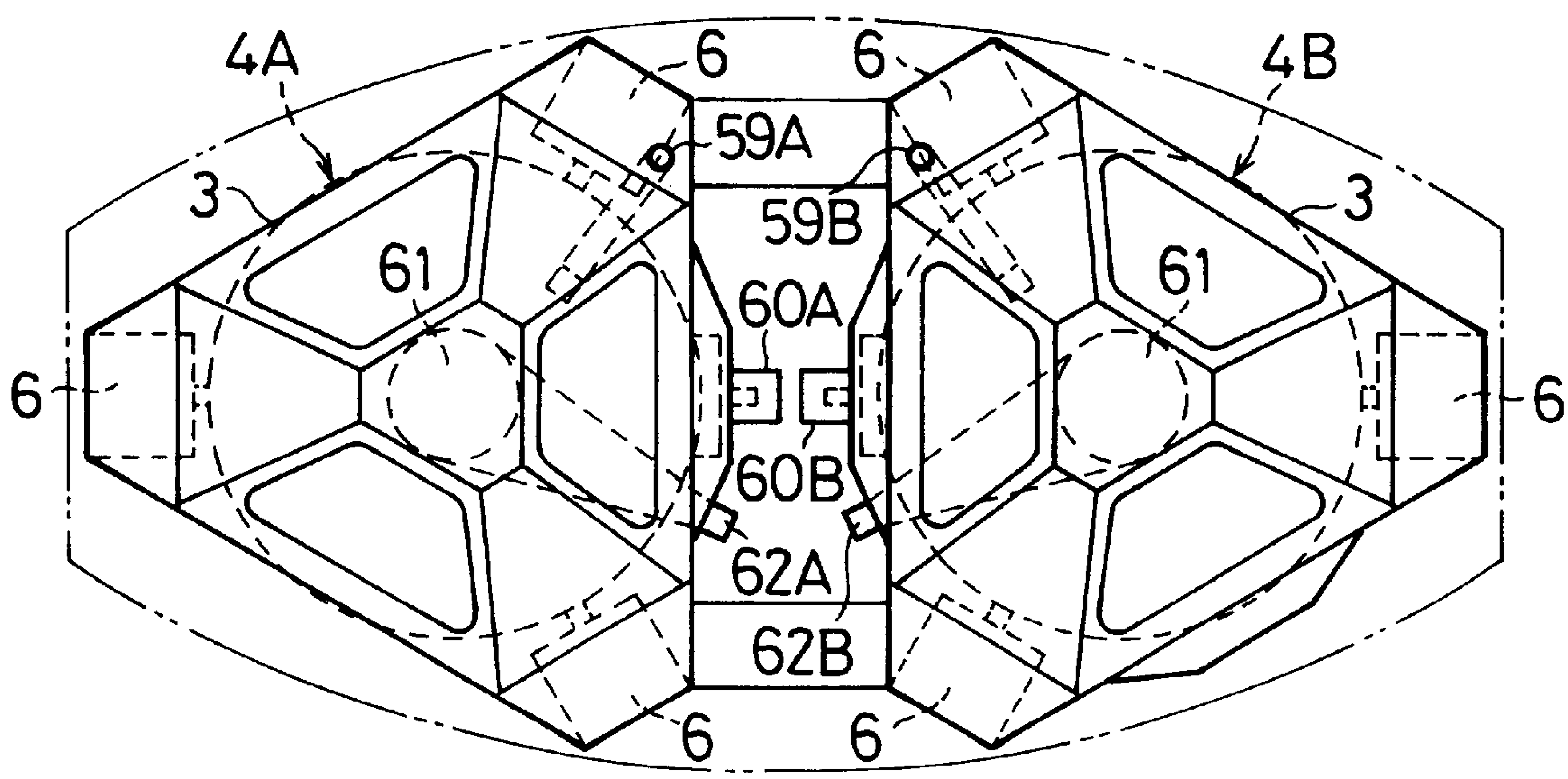


FIG. 12

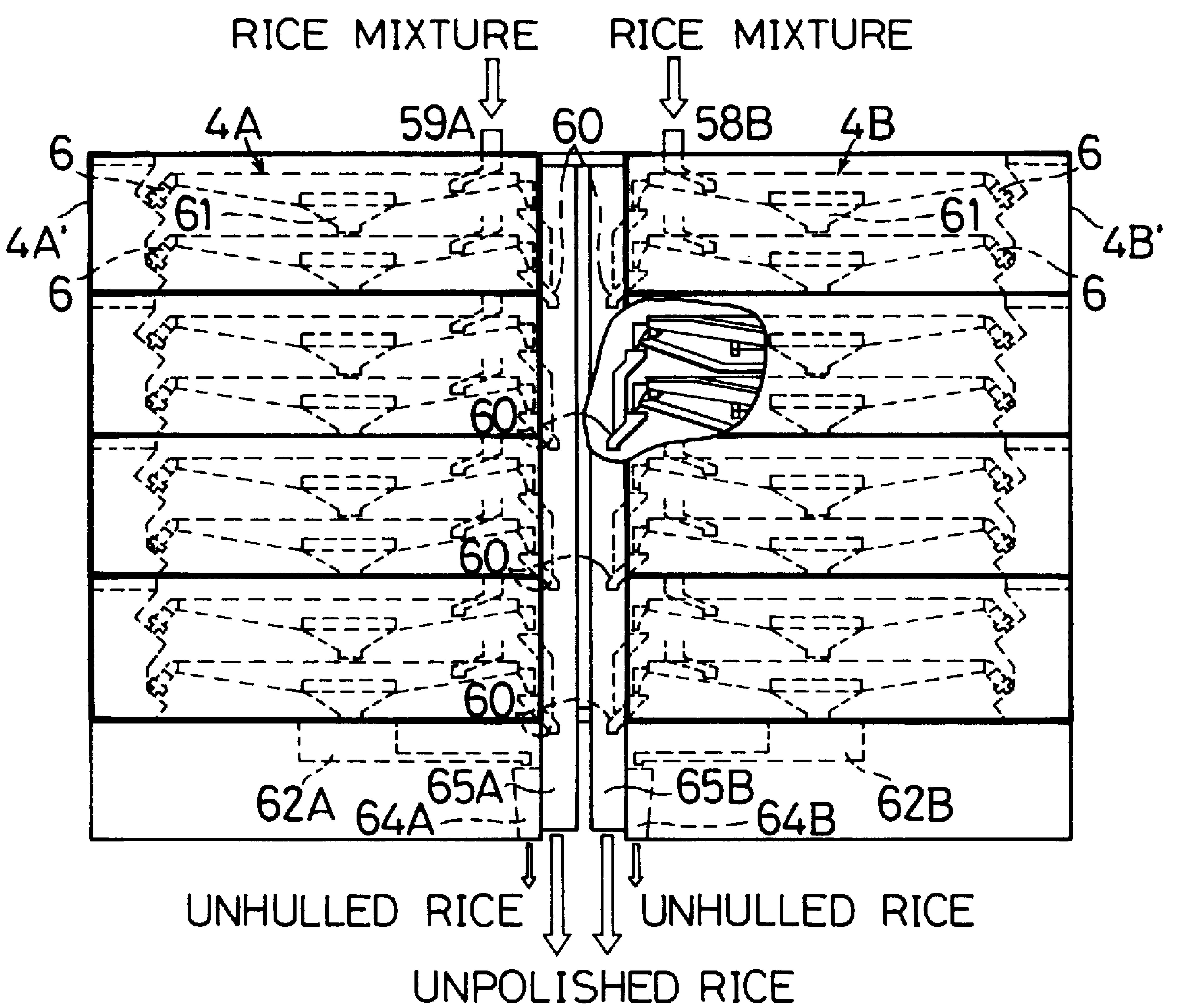

RICE MIXTURE
RICE MIXTURE
4A
59A
60
58B
4B
6
6
61
61
4A'
4B'
6
6
60
60
60
62A
64A
65A
65B
64B
62B
UNHULLED RICE
UNHULLED RICE
UNPOLISHED RICE

FIG. 13
PRIOR ART

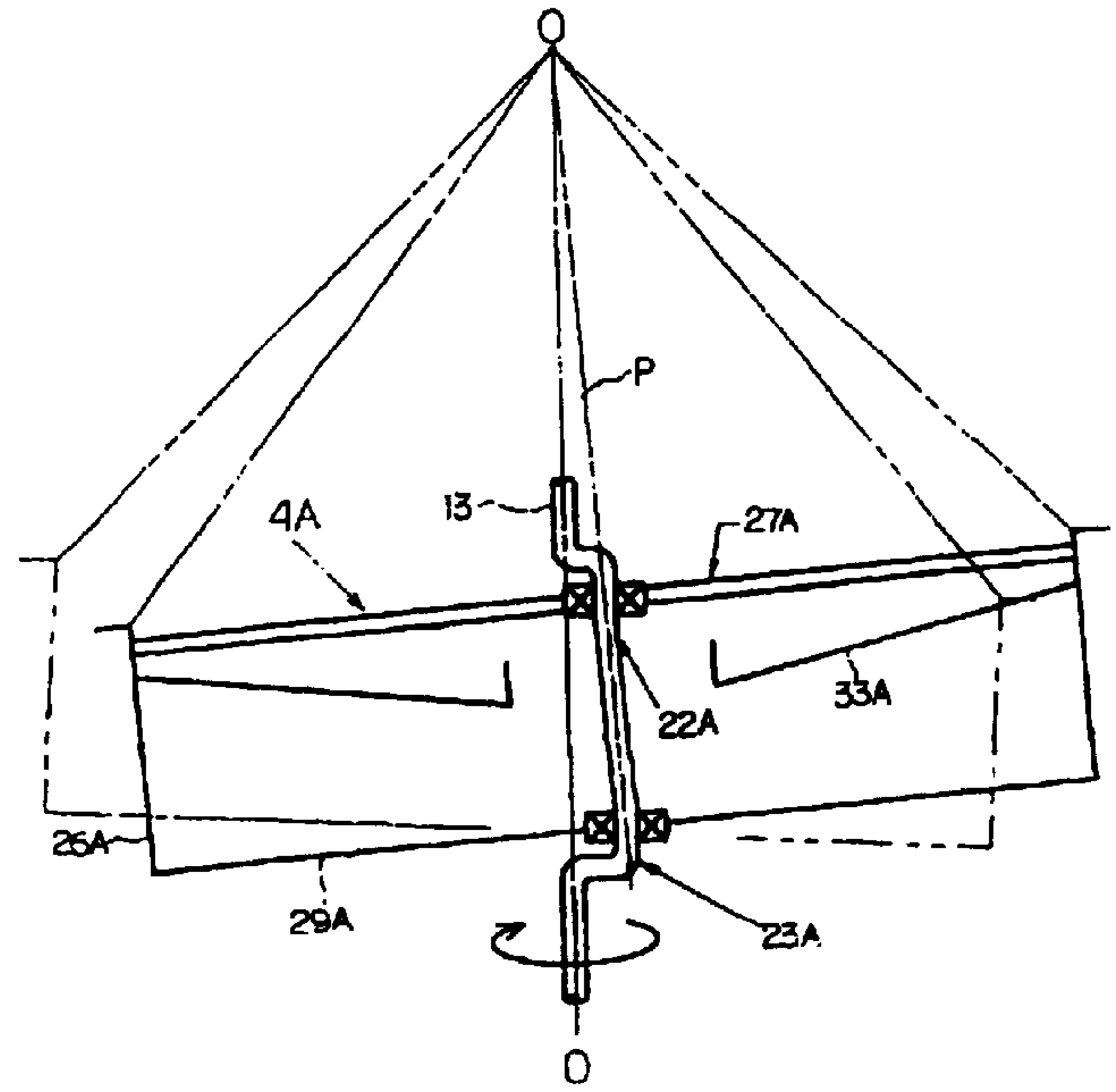


FIG. 14
PRIOR ART

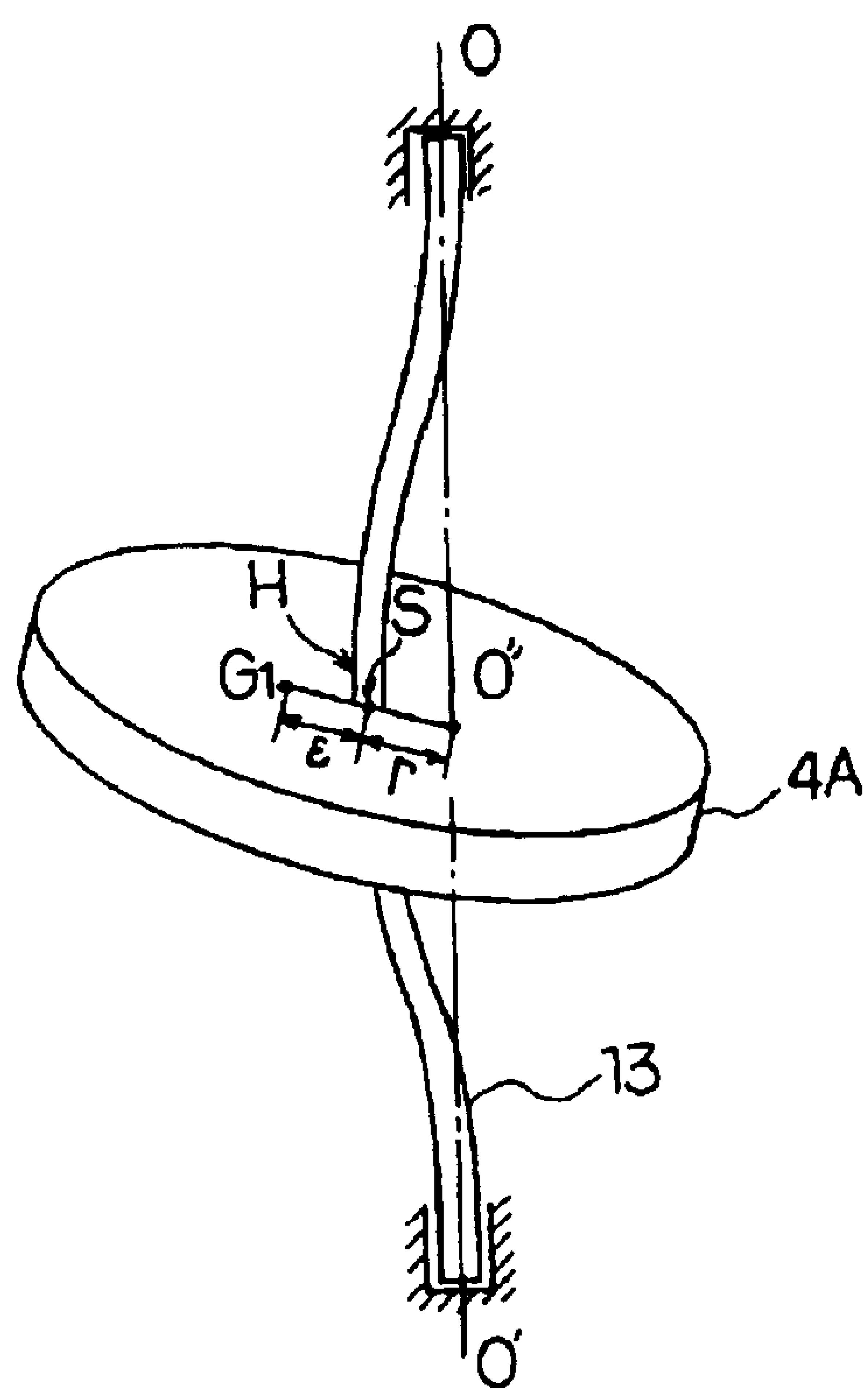


FIG. 15
PRIOR ART

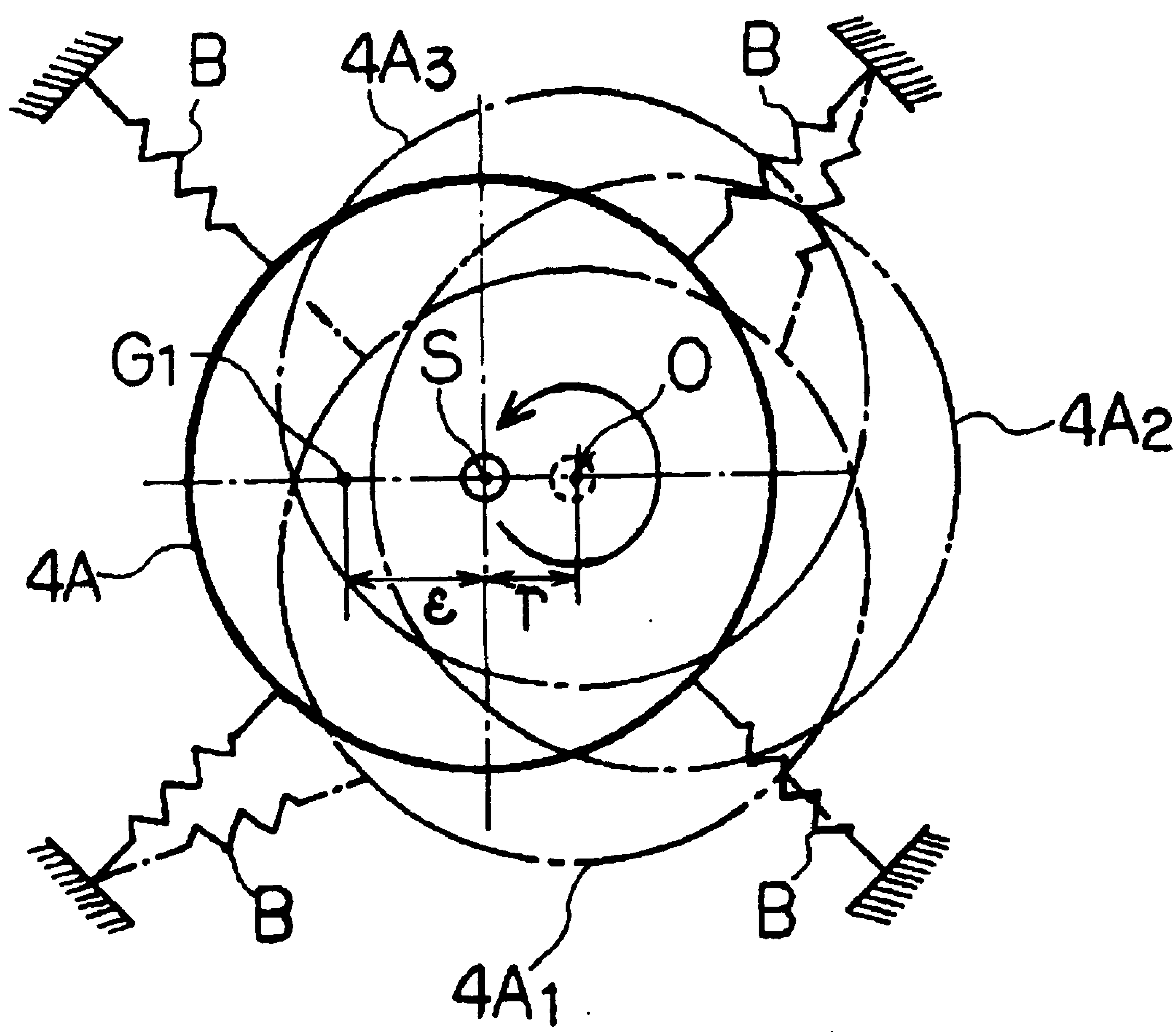


FIG. 16

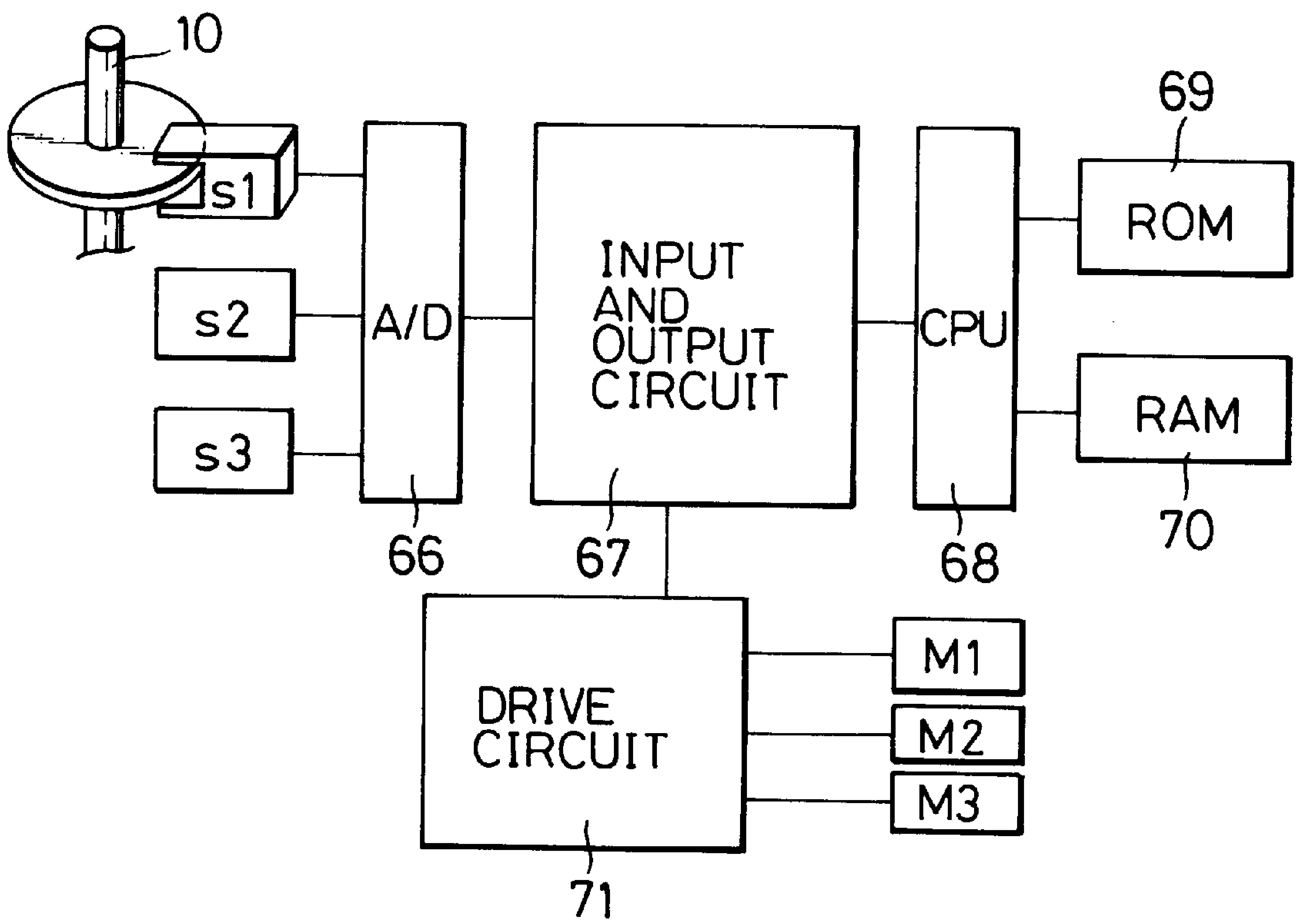

10
s1
s2
s3
A/D
66
INPUT AND OUTPUT CIRCUIT
67
CPU
68
69
ROM
RAM
70
DRIVE CIRCUIT
71
M1
M2
M3

FIG. 17

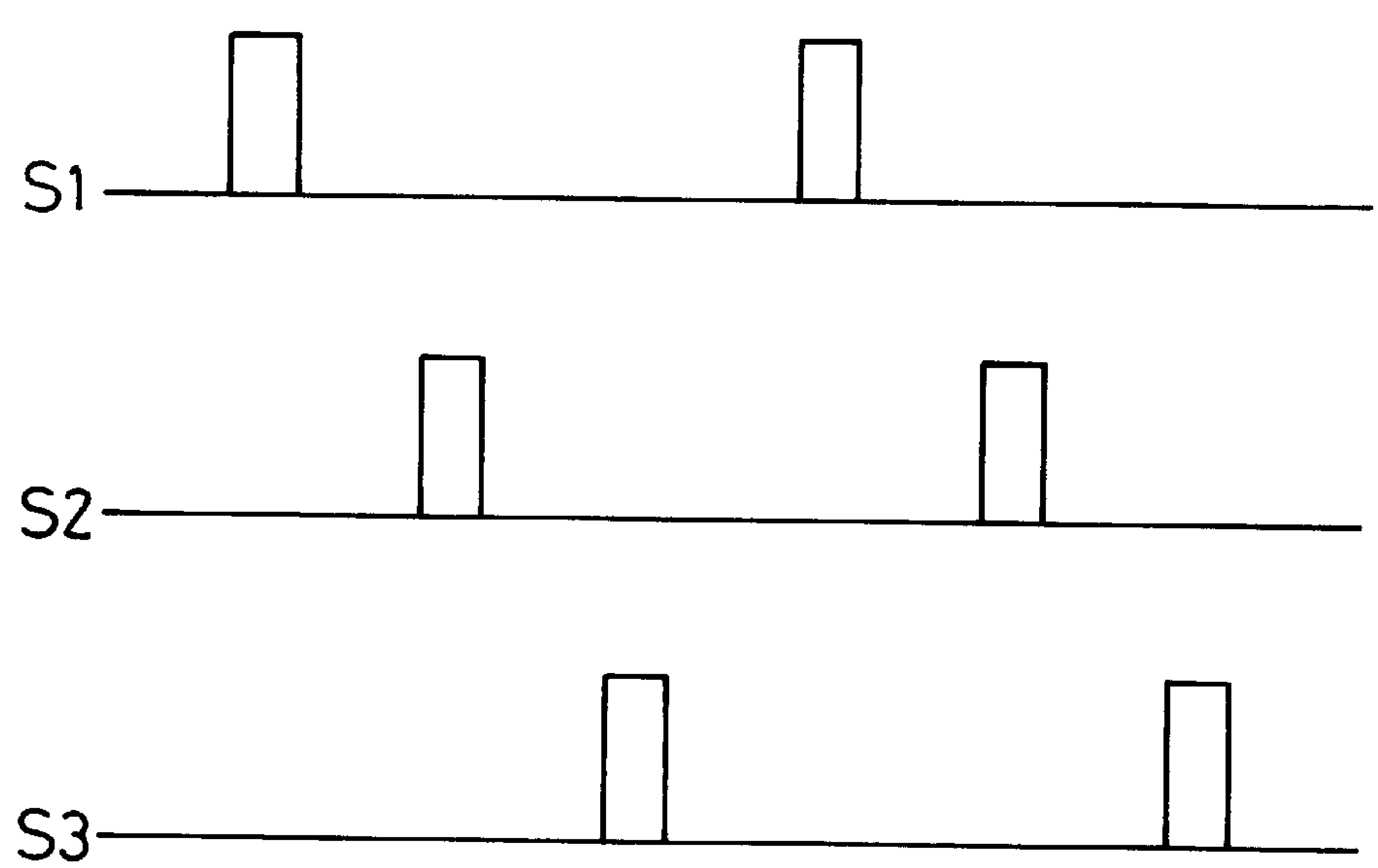
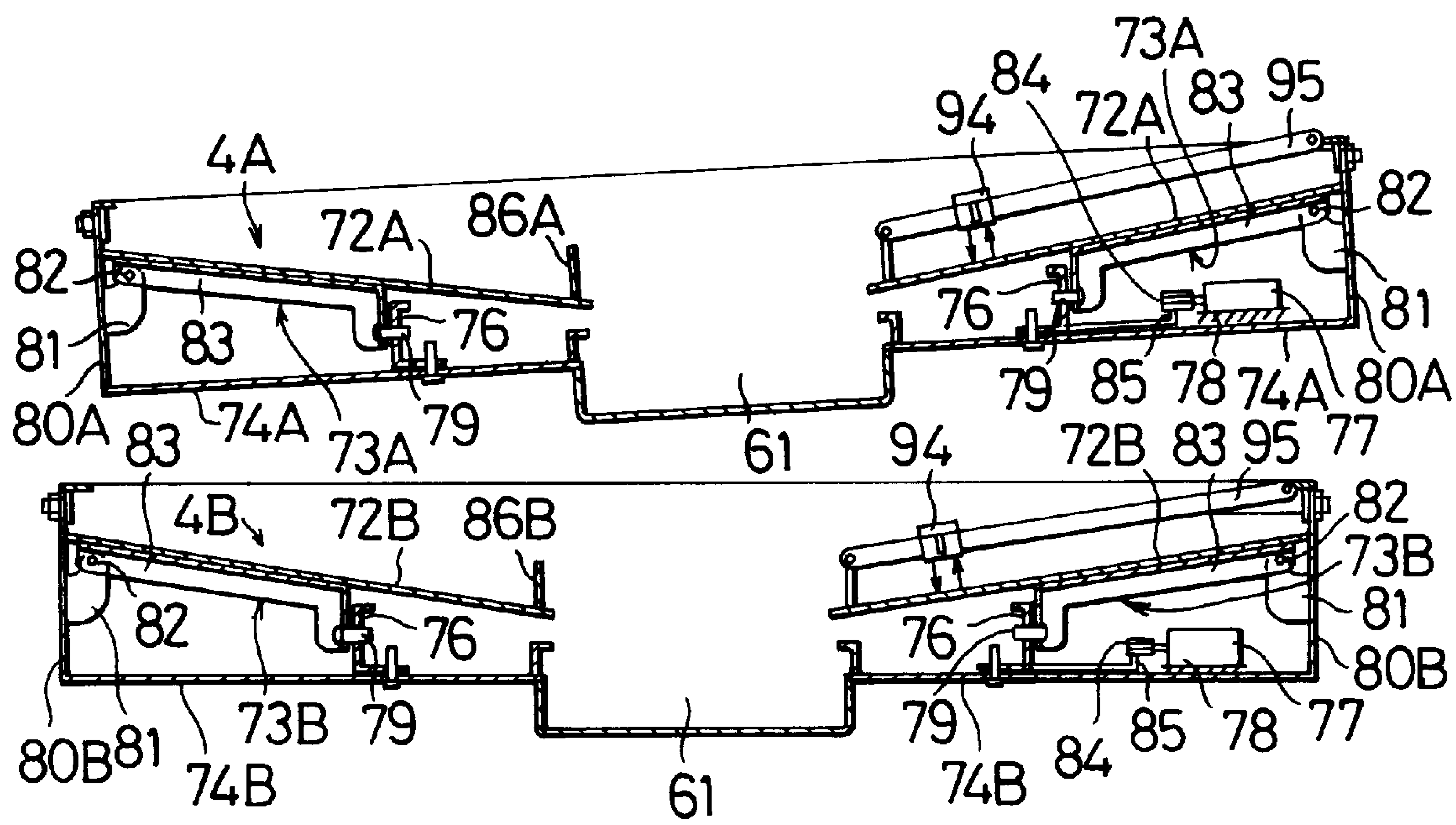

S1
S2
S3

FIG. 18


4A
72A
86A
82
83
76
81
80A
74A
73A
79
61
73A
84
94
72A
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95
82
76
81
79
85
78
74A
80A
77
4B
72B
86B
83
82
73B
79
80B
81
74B
94
72B
83
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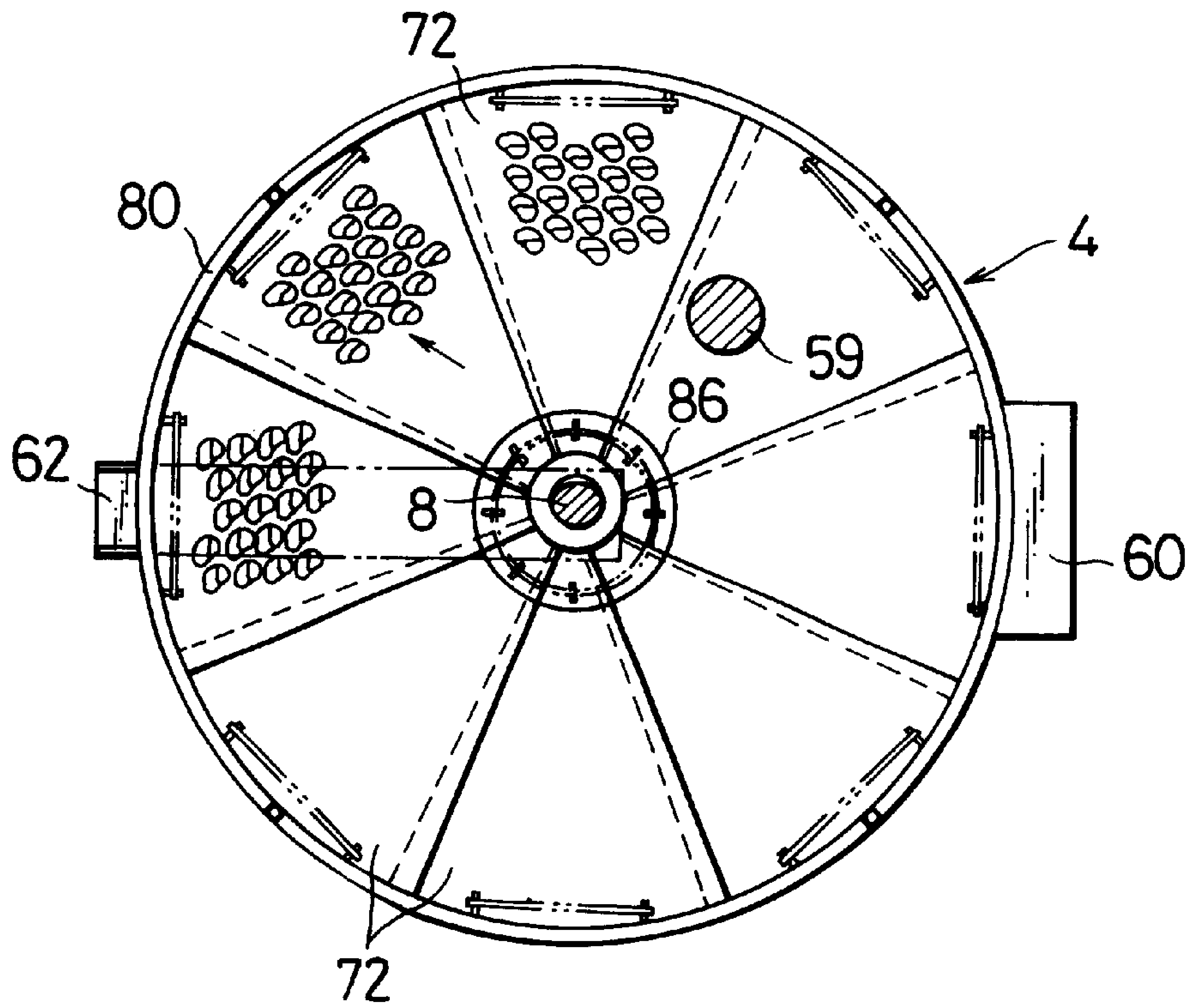
82
73B
81
80B
76
79
74B
84
85
78
77
61

FIG. 19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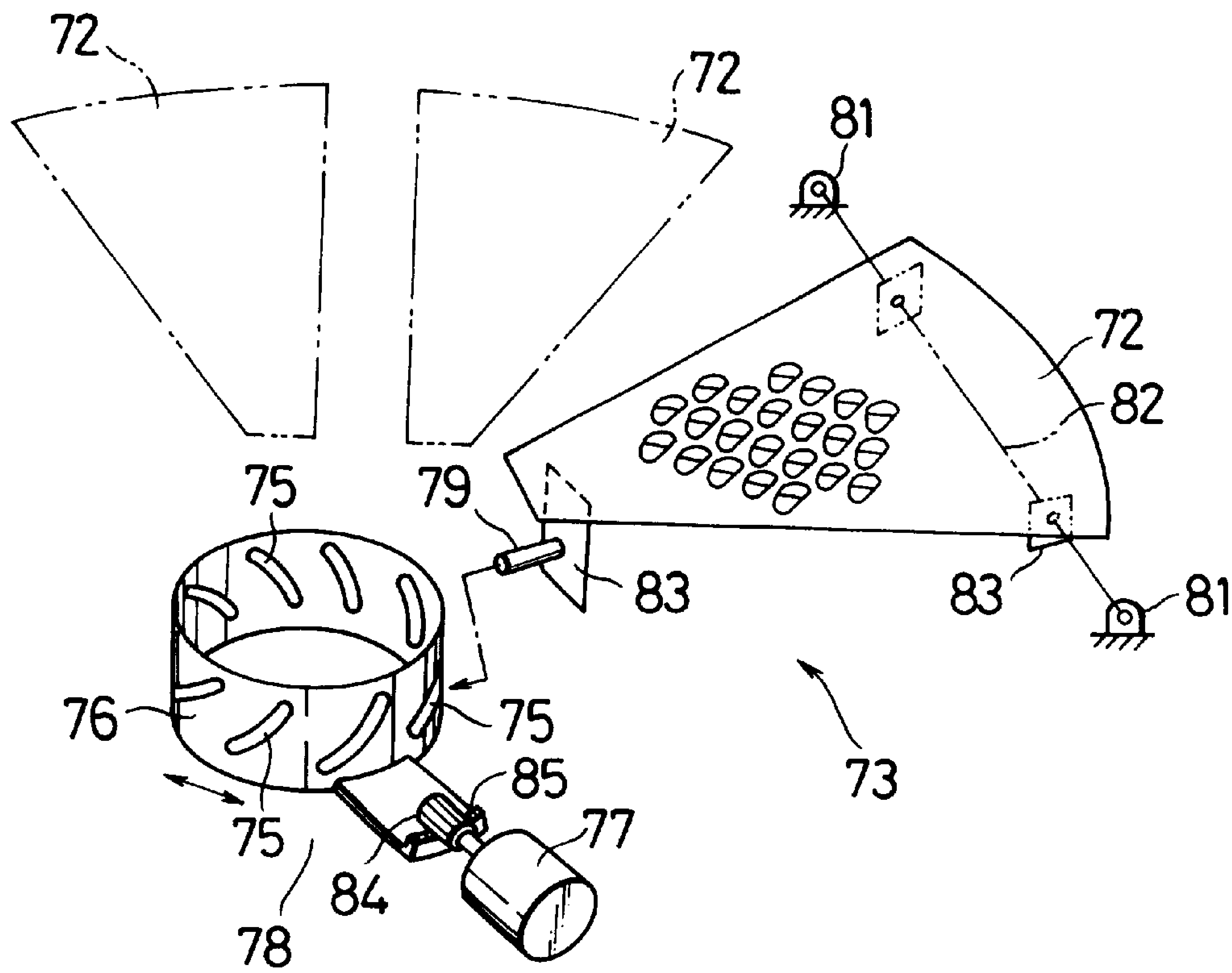
80
4
59
86
62
8
60
72

FIG. 20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72
82
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84
78

FIG. 21

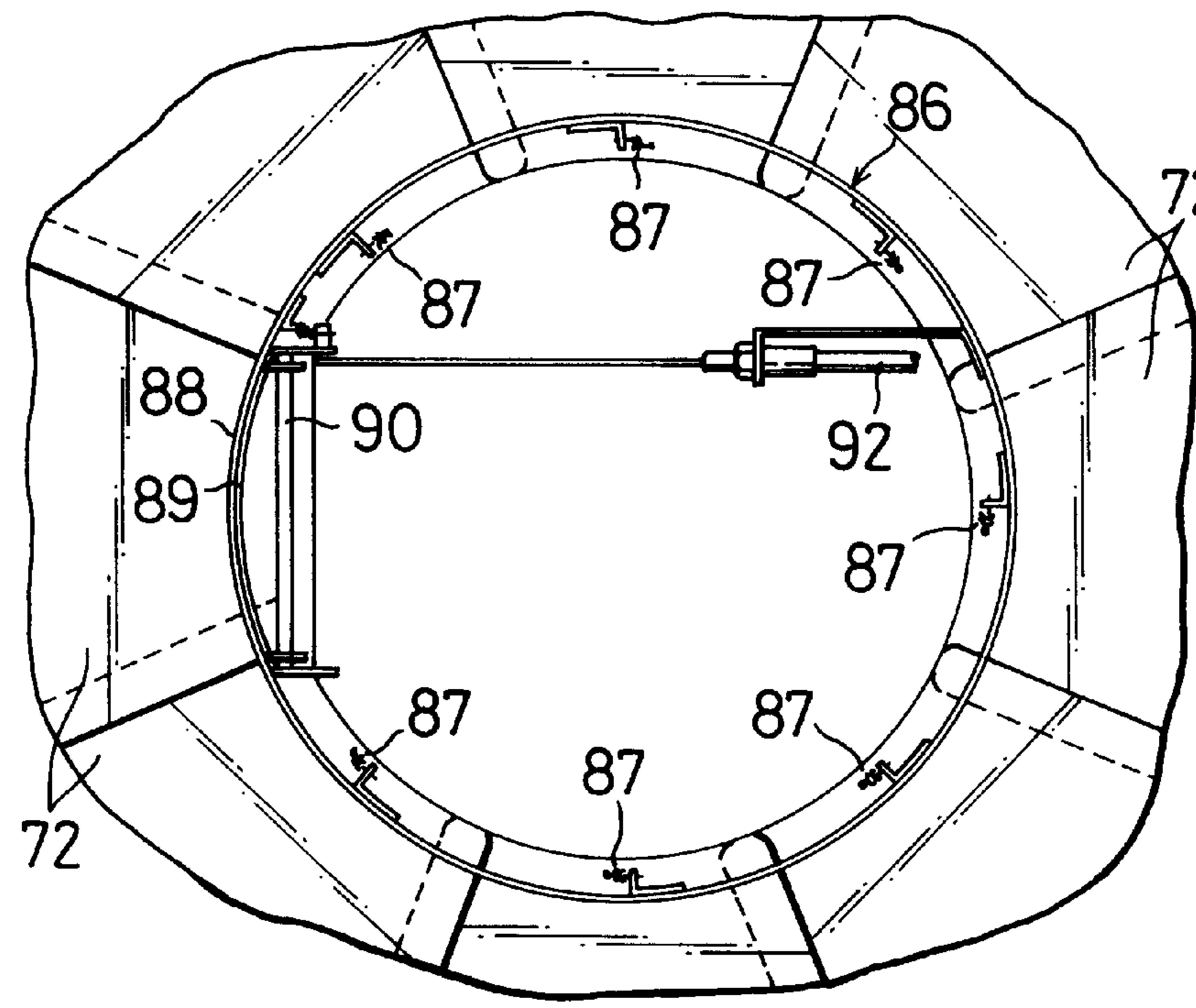

86
72
87
87
87
88
90
92
89
87
87
87
87
72

FIG. 22

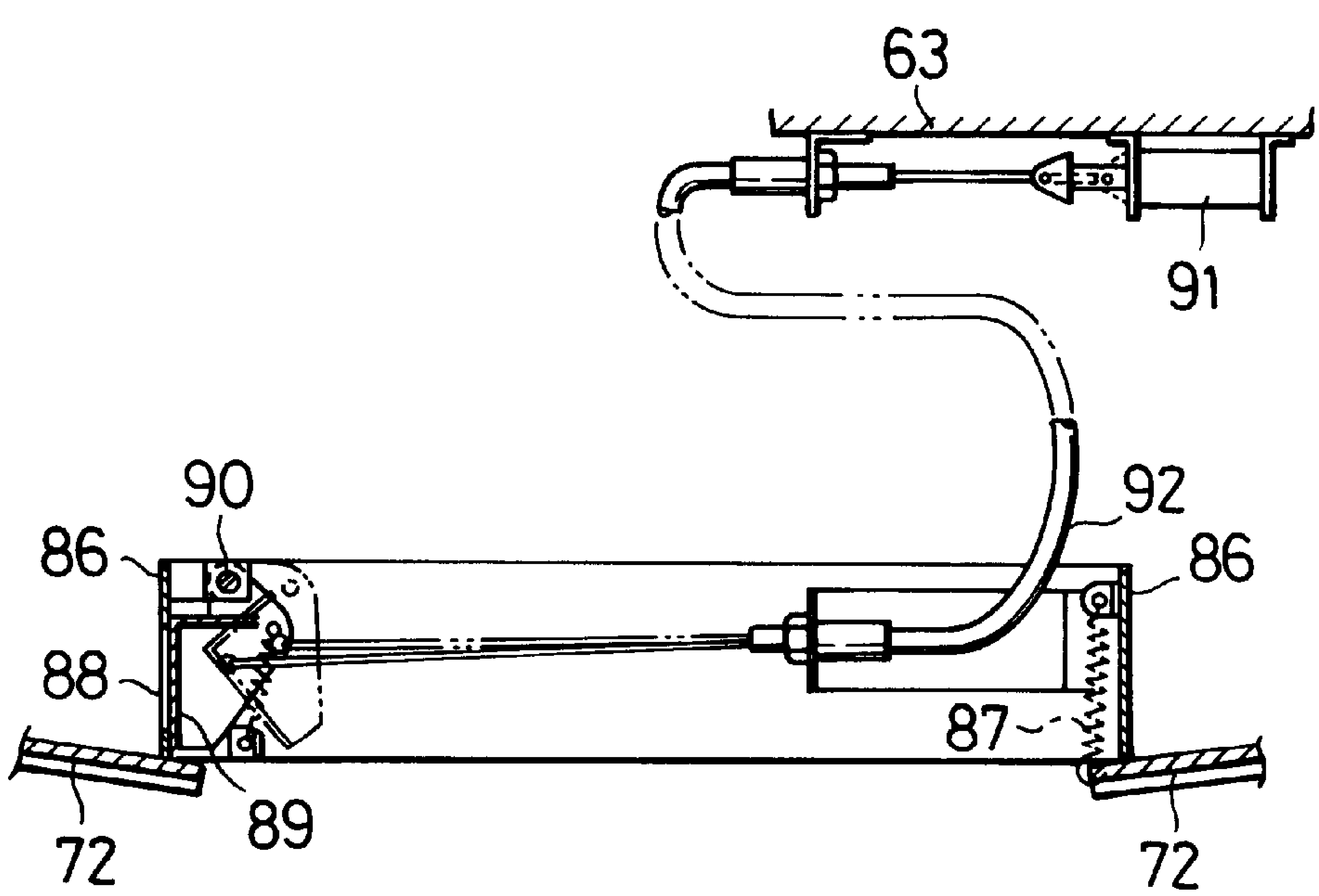

63
91
90
92
86
86
88
87
89
72
72

FIG. 23

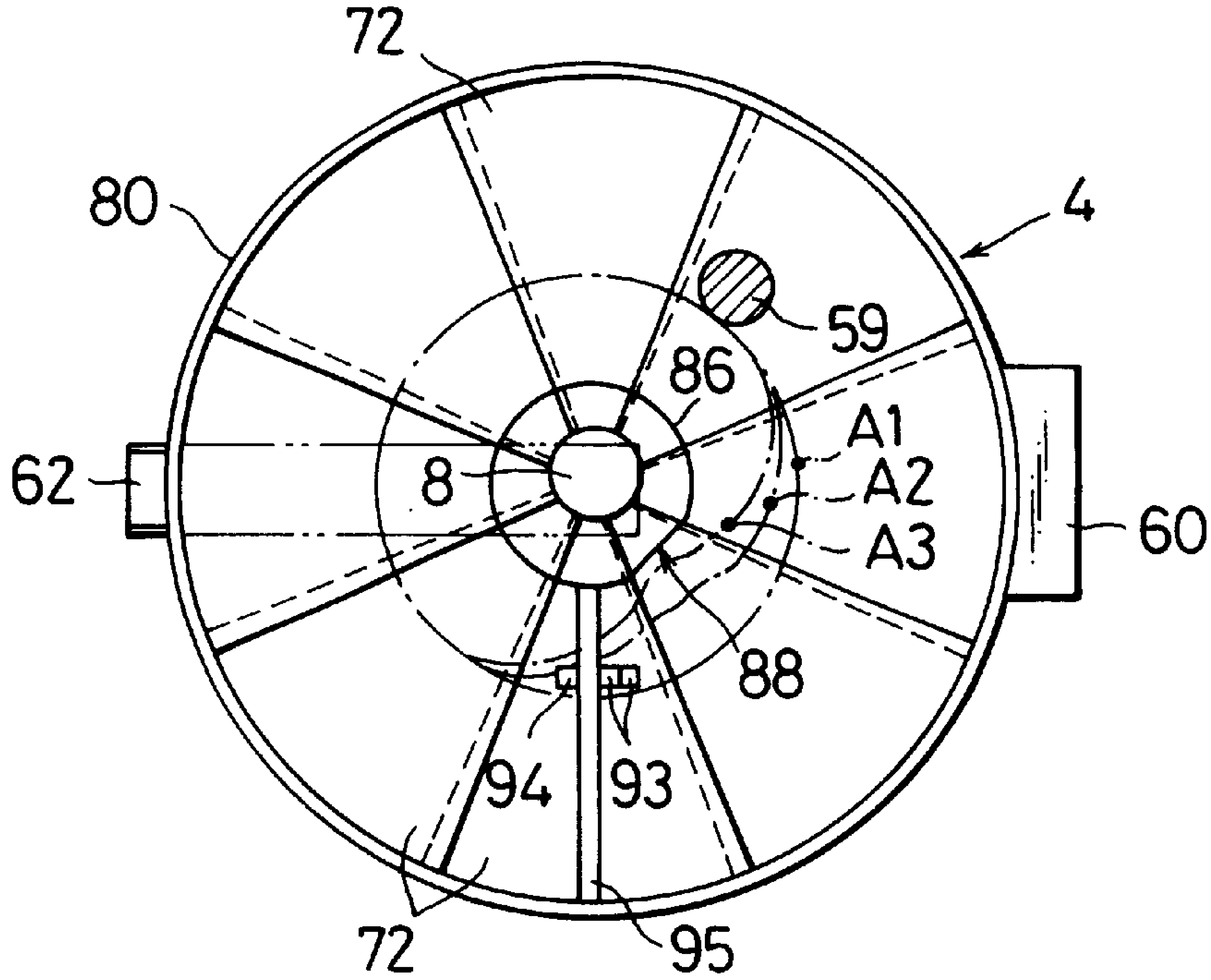


FIG. 24

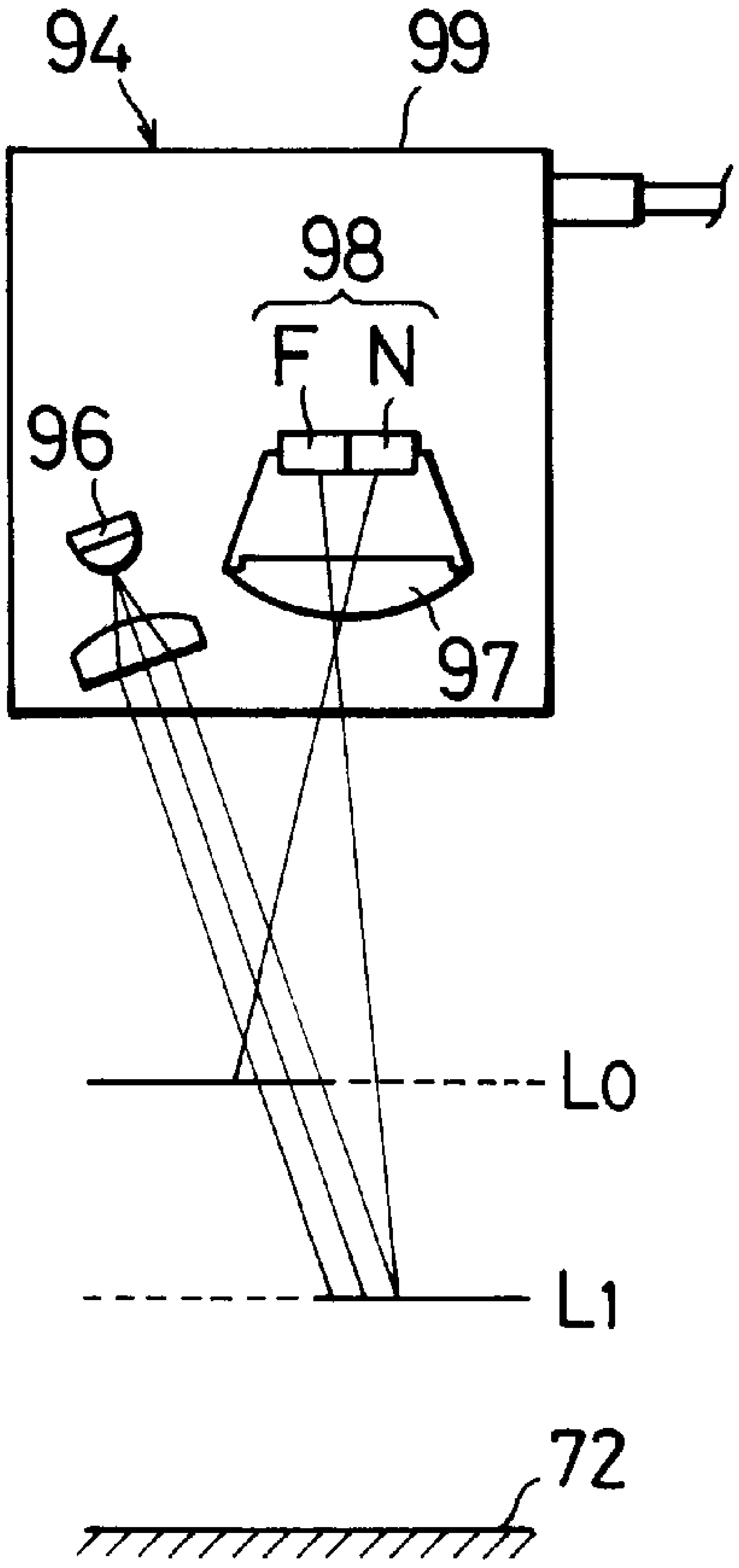


FIG. 25

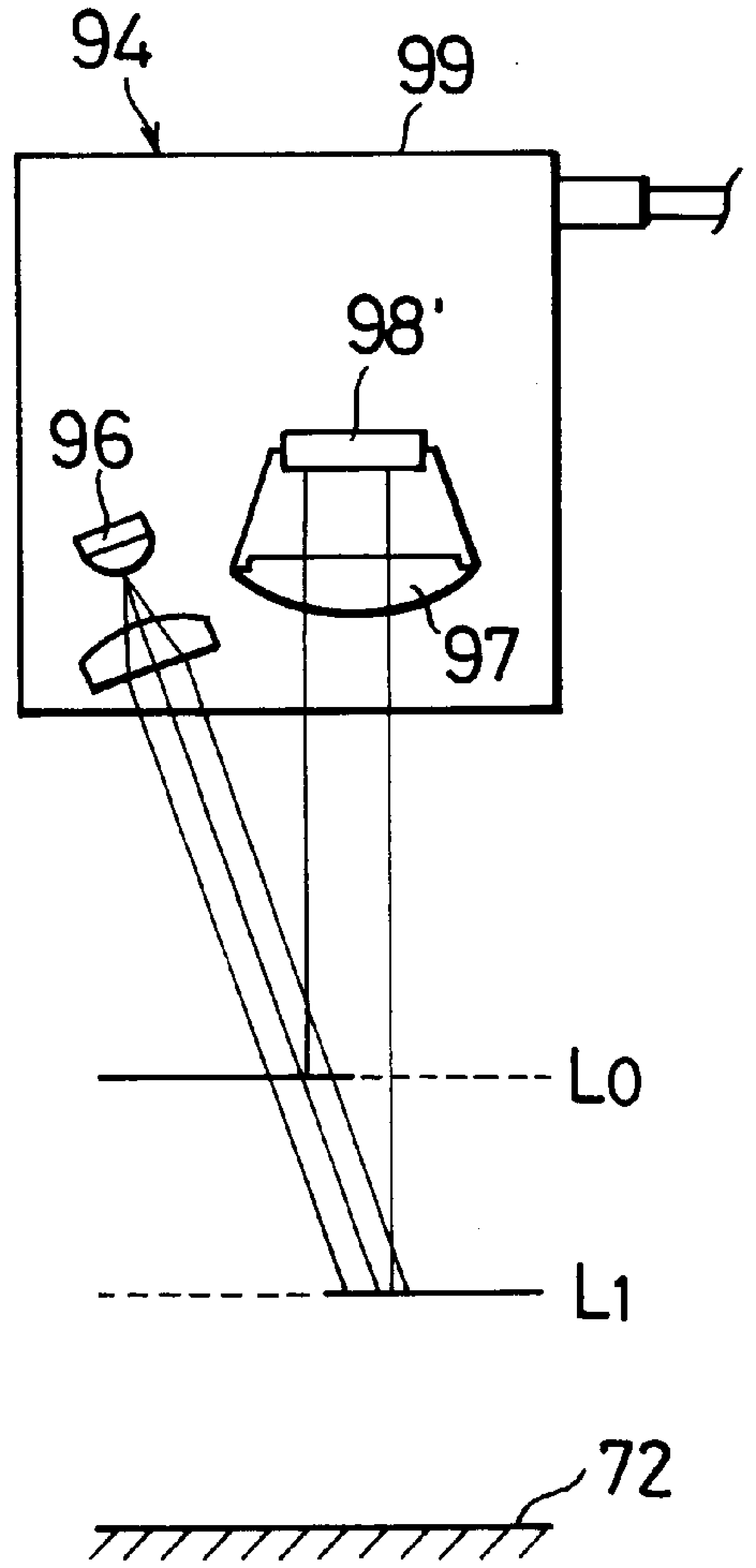
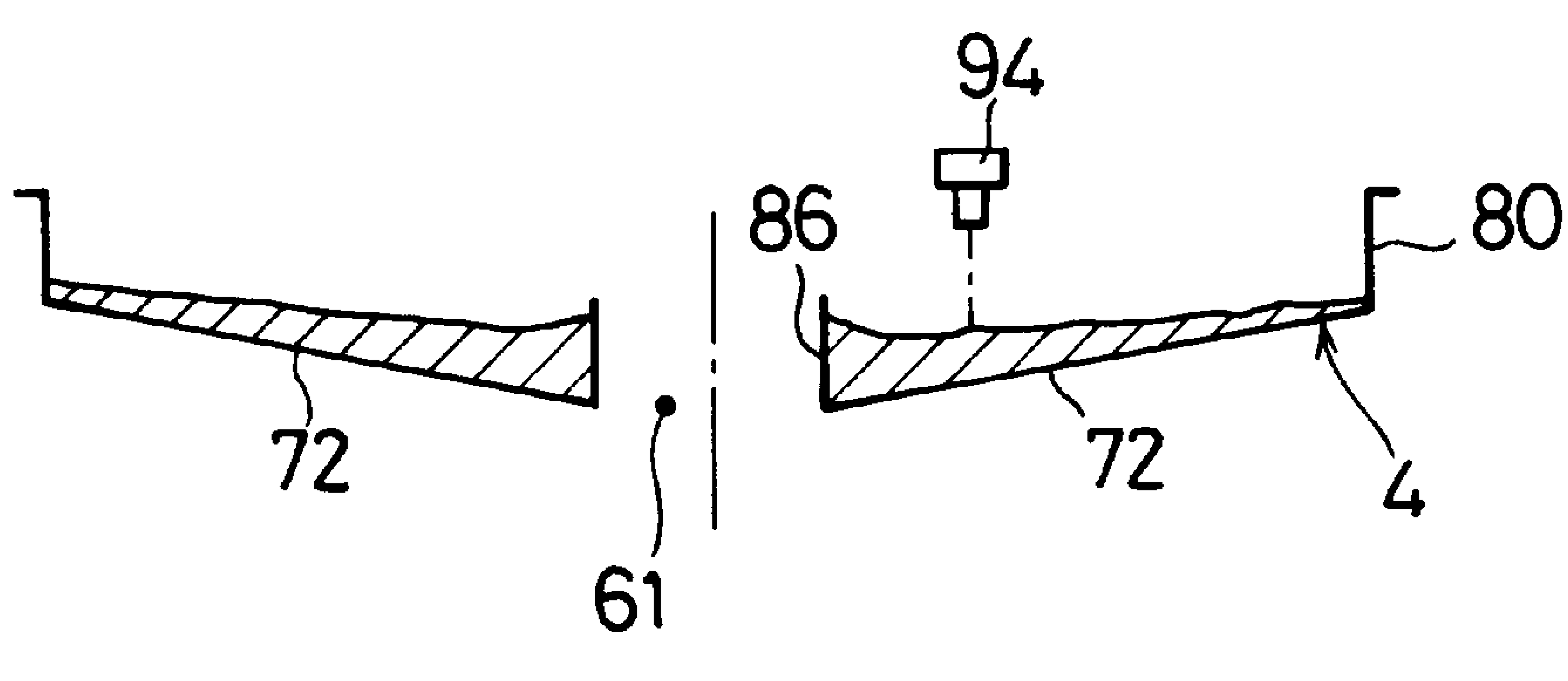


FIG. 26



ROTARY SHAKING SEPARATOR

FIELD OF THE INVENTION

The present invention relates to a separator for separating unhulled rice and unpolished rice from each other after hulling rice, and in particular, to such type of separator that rotationally shakes a circular separating vessel for the separation.

DESCRIPTION OF THE PRIOR ART

The inventor of the present invention has suggested in the Japanese Patent Application No. H11-106959 a rotary shaking separator which can reduce a space for installing the separator while maintaining separating accuracy of each of a plurality of circular separating vessels at a certain level even if they are arranged in multi-rows. To describe the configuration of this separator with reference to FIG. **13**, the separator is designed to have a geometry in which a vertical supporting point "O" of an eccentric revolving motion is arranged above a shaft center of a rotary shaft **13** and an inclination line "P" is extended downwardly from said vertical supporting point "O" with a predetermined inclination angle, and a separating vessel **4**A is rotatably mounted to an eccentric portion **22**A, **23**A formed on said inclination line "P".

FIG. **14** is a schematic view illustrating said separating vessel **4**A being revolved by the rotary shaft **13**, and FIG. **15** is a schematic top view of the separating vessel **4**A. Referring to FIGS. **14** and **15**, the separating vessel **4**A is supported by an eccentric portion "H" of the rotary shaft **13** inserted through a central portion "S" of the separating vessel **4**A to allow the rotary shaft **13** to rotate with respect thereto, while a peripheral edge portion of the separating vessel **4**A is supported by a plurality of springs "B" to prevent free rotation thereof (the separating vessel **4**A is held and restrained at the central portion thereof by the rotary shaft **13** and at the peripheral edge portion thereof by the plurality of springs "B" respectively so that the motion of the separating vessel **4**A is limited to a certain range). As the rotary shaft **13** rotates, the separating vessel **4**A is revolved around the rotation center "O" of the rotary shaft **13** by an eccentricity amount "r" (as shown by dotted lines **4**A**1**, **4**A**2** and **4**A**3** in FIG. **15**), and thereby unhulled rice and unpolished rice in the rice mixture are separated from each other on the separating vessel **4**A so that the unhulled rice is discharged through a unhulled rice discharging port disposed in the vicinity of the central portion "S" and the unpolished rice is discharged through an unpolished rice discharging port disposed in the vicinity of the peripheral edge portion.

As for said separating vessel **4**A, the rotary shaft **13** is designed to rotate under the condition that a center of gravity "G" of the separating vessel **4**A is on the central portion "S" of the separating vessel **4**A, but if supply of material to be separated is increased, the center of gravity is offset from the central portion "S" by the eccentricity amount "ε", which may result in a failure in separation (G1 in FIG. **14**). Furthermore, when stiffness of the springs "B" for preventing the free rotation of the separating vessel **4**A gets weaker through a long-term service, a travelling distance of said materials placed on the separating plates of the separating vessel **4**A to be separated thereby is possibly varied even along the same radii symmetrical to each other around the central portion "S", resulting in a failure in separation at some locations in the same separating vessel **4**A.

Yet further, because the rotary shaft **13** is inserted through the central portion "S" of the separating vessel **4**A, the

unhulled rice discharging port is necessarily designed to be narrow, which has exhibited some disadvantages that mounting of components is difficult, maintenance thereof is troublesome, and discharge of unhulled rice is not facilitated.

SUMMARY OF THE INVENTION

In the light of the problems described above, an object of the present invention is to provide a rotary shaking separator which prevents a failure in separation in the same separating vessel, allowing a constant separating accuracy to be maintained, without requiring a rotary shaft to be inserted through a central portion of the separating vessel.

To solve the problems described above, the present invention provides in the view of technology a rotary shaking separator comprising a separating vessel having a plurality of segmental separating plates arranged in a cone-shape form and a drive means for rotationally shaking said separating vessel so that once material to be separated, which is mixture composed of unhulled rice and unpolished rice, is supplied into a predetermined location of said separating vessel, said unhulled lice is discharged from a peripheral edge portion of said separating vessel and said unpolished rice is discharged from a central bottom portion of said separating vessel, wherein said separating vessel is supported by a plurality of drive means arranged in peripheral edge portions thereof on the same radii from the center of said separating vessel with arc lengths thereof being equal to one another, and said peripheral edge portions of said separating vessel are sequentially driven elliptically by said plurality of drive means to rotationally shake the whole of said separating vessel. Owing to this arrangement, since the mixture of unhulled rice and unpolished rice supplied into the separating vessel has greater acceleration in the vicinity of the peripheral portions, the unpolished rice having smaller grain size and greater specific gravity is carried toward the peripheral edge direction to be discharged from an unpolished rice discharging port, while the unhulled rice having greater grain size and smaller specific gravity slides down along the cone-shaped separating plates to be discharged from a central bottom portion of the separating vessel, thereby making it possible to retain a constant degree of separating accuracy without any failure in separation which might otherwise occur on the same separating plate and further to provide a rotary shaking separator which requires no rotary shaft inserted through the central portion of the separating vessel.

Further, it is preferable that the rotary shaking separator has a plurality of electric motors each being provided corresponding to each of a plurality of drive means. In this case, it is preferable that, in order to operate the plurality of electric motors synchronously, the apparatus comprises a measuring device for measuring a number of revolutions of a drive shaft of each of the electric motors and a controller for controlling every electric motor to be driven in a specific number of revolution based on the outputs from the measuring device as well as for actuating every electric motor synchronously with a specific phase delay therebetween, so that the drive means may be protected from being damaged by a possible over loading which might occur when the number of revolutions of each electric motor is varied or the phase thereof is shifted improperly.

Further, since a single electric motor may be used to actuate said plurality of drive means to eliminate any kinds of devices to operate a plurality of electric motors synchronously, the number of controllers and electric motors required for synchronous operation could be reduced, and thus a manufacturing cost could also be reduced.

When a plurality of electric motors are provided for a plurality of drive means so as to correspond one by one with each other, such type of drive means may be employed that comprises: an input shaft rotatably arranged vertically so as to transmit the revolution from an electric motor; a swash plate cam axially attached to said input shaft; and an output shaft which follows displacement caused by the revolution of said swash plate cam to make an elliptical locus. Further, another type of drive means may also be employed which comprises: an input shaft rotatably arranged vertically so as to transmit the revolution from an electric motor; a cam member having a swash plate cam attached thereto by inserting said input shaft therethrough; and an output shaft which is slidably moved on said swash plate cam driven by the revolution of said input shaft to make an elliptical locus by a displacement rotationally moving up and down. Yet further, another type of drive means may also be employed which comprises: an input shaft rotatably arranged obliquely so as to transmit the revolution from an electric motor; an eccentric shaft axially attached to said input shaft; a crank plate for converting a true circular motion of said eccentric shaft to an elliptical motion; and an output shaft axially attached to said crank plate for making an elliptical locus.

On the other hand, in the case where a single electric motor is used to actuate said plurality of drive means, such type of drive means may be employed that comprises: an input shaft rotatably arranged laterally so as to transmit the revolution from an electric motor; an intermediate shaft connected to said input shaft via a universal joint; and an eccentric shaft axially attached to said intermediate shaft.

Furthermore, said separating vessels arranged into multi-rows could enhance a separating ability in comparison with the separating vessel in single-row.

Still further, an apparatus according to the present invention further comprises: a circular dam disposed on a separating plate in a center of said separating vessel and having a unhulled rice discharging port; a shutter for opening or closing said unhulled rice discharging port; and a unit for actuating said shutter; wherein, said unit for actuating said shutter is actuated in response to an output signal from a unhulled rice/unpolished rice detection sensor for distinguishing the unhulled rice and unpolished rice from each other on the separating plates, so that a discharge amount of the unhulled rice could be controlled based on a proportion of the unhulled rice layer to the unpolished rice layer on the cone-shaped separating plates during a period from the beginning of separation throughout the separating operation.

Yet further, since each of said separating plates of said separating vessel is constructed such that an inclination angle thereof is allowed to be regulated respectively and said apparatus further comprises a regulator unit for regulating the inclination angle of said separating plates, the inclination angle or a slope of he separating plate of the separating vessel can be adjusted, so that a thickness of the layer of rice mixture on the separating plates can be controlled appropriately.

Besides, since the apparatus according to the present invention further comprises a level sensor for detecting a level of a layer thickness of rice mixture on said separating plates so that when said level sensor detects the thickness of the layer of said rice mixture being over or under a predetermined level, said regulator unit is actuated to regulate the inclination angle of the separating plates toward a gentle slope direction or a steep slope direction, the rice mixture can be distributed over the separating plates with the level in layer thickness being higher in the central side gradually getting lower toward the peripheral edge side thus to reduce a possible risk that the unhulled rice is discharged by centrifugal force through the unpolished rice discharging port.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic plan view illustrating a rotary shaking separator according to the present invention;

FIG. **2** is a schematic longitudinal cross sectional view illustrating a rotary shaking separator according to the present invention being driven;

FIG. **3** is a perspective view of a swash plate cam C;

FIG. **4** shows an embodiment of a drive means to which the swash plate cam C is applied;

FIG. **5** is a schematic plan view illustrating an alternative embodiment of the drive means;

FIG. **6** is a schematic plan view of a configuration in which four actuators "A" are operated by a single motor shaft;

FIG. **7** is a schematic side elevation view of the configuration of FIG. **6**, viewed from the motor shaft side;

FIG. **8** is an enlarged view illustrating a connection of a support member with a separating vessel;

FIG. **9** is a schematic longitudinal cross sectional view illustrating an alternative embodiment of the drive means;

FIG. **10** is an enlarged view of a crank plate;

FIG. **11** is a schematic plan view of a multi-row model of the rotary shaking separator;

FIG. **12** is a schematic cross sectional side elevation view of a multi-row model of the rotary shaking separator;

FIG. **13** is a schematic view of configuration of a rotary shaking separator according to the prior art;

FIG. **14** is a schematic view of the rotary shaking separator according to the prior art, illustrating a selecting frame **4A** being rotated by an eccentric rotary shaft **13**;

FIG. **15** is a schematic top view of the selecting frame **4A** in the rotary shaking separator according to the prior art;

FIG. **16** is a block diagram of a controller for synchronously driving a plurality of electric motors;

FIG. **17** is a diagram of pulse signals of sensors **S1**, **S2** and **S3** for measuring the revolution numbers of rotary shafts of respective motors;

FIG. **18** is a longitudinal cross sectional view illustrating internal components of a separating vessel;

FIG. **19** is a schematic plan view of the separating vessel;

FIG. **20** is a perspective view of a mechanism for regulating an inclination angle of separating plates;

FIG. **21** is a plan view of a circular dam arranged on the separating plates;

FIG. **22** is a longitudinal cross sectional view of FIG. **21**;

FIG. **23** is a plan view of a separating vessel equipped with a unhulled rice/unpolished rice detection sensor and a level sensor;

FIG. **24** is a diagram illustrating an operation of a level sensor in detecting a layer thickness;

FIG. **25** is a diagram illustrating an operation of another level sensor in detecting a layer thickness; and

FIG. **26** is a diagram illustrating a relation between a level sensor and a separating condition on separating plates.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present invention will be described with reference to the attached drawings. Although in the present embodiment the description focuses on a rotary shaking separator for separating mainly grain mixture composed of unhulled rice and unpolished rice into respective groups, it should be appreciated that the present invention is not limited to this application but is applied to any rotary shaking separator which separates and sorts out refined product from extraneous substance, such as oats from foreign matter, rubber from foreign matter, sawdust from foreign matter, buckwheat from buckwheat hull, plastic from foreign matter, and the likes. FIG. **1** is a schematic plan view of a rotary shaking separator according to the present invention while FIG. **2** is a schematic longitudinal cross sectional view, illustrating a rotary shaking separator being driven. Main part of a rotary shaking separator **1** comprises a cone-shaped separating vessel **4** having a central bottom portion **2** formed to be concave and a peripheral edge portion **3** formed to be into higher level, a plurality of segmental separating plates **5** laid within said separating vessel **4** in a shape of circle in plan view, a plurality of drive means **6** for supporting the peripheral edge portion **3** of the separating vessel **4** and for rotationally shaking the separating vessel **4**, a supply means **7** for supplying mixture composed of unhulled rice and unpolished rice into a specified location "S" on the segmental separating plates **5**, a unhulled rice discharging port **8** for discharging unhulled rice from the central bottom portion **2**, and an unpolished rice discharging port **9** for discharging unpolished rice from the peripheral edge portion **3** of the separating vessel **4**.

Said drive means **6** is composed of, for example, three pieces of drive means in total, each of the drive means **6** being arranged in each of three sections which are created by dividing the arc of the peripheral edge **3** of the separating vessel **4** by three at every 120° (see FIG. **1**). One end of each of the drive means **6** is defined as fixed end "K" to constrain a motion, while the other end thereof is defined as an actuator "A" to support the separating vessel **4** and bring the container into a rotationally shaking motion. Three drive means **6** are correspondingly provided with three electric motors "M" as one to one respectively, and in the case where the three electric motors M1, M2 and M3 are driven synchronously, there may be preferably provided further with a measuring means for measuring the number of revolutions of drive shaft of each of the electric motors M1, M2 and M3 as shown in FIG. **16**, and a controller for controlling all of the electric motors to have the predetermined same number of revolutions based on the outputs from said measuring means and also for actuating respective electric motors synchronously with a specified phase delay therebetween. FIG. **17** shows pulse signals of sensors S1, S2 and S3 for respectively measuring the number of revolutions of a rotary shaft of each of the electric motors, and the operation of the electric motor will be described with reference to FIGS. **16** and **17**. A signal from each of the sensors S1, S2 and S3 for measuring the number of revolutions of the drive shaft **10** of each motor is analogue-to-digital-converted into a pulse signal as shown in FIG. **17** by an A/D converter **66**, which pulse signal in turn is transmitted to a CPU **68** via an input/output circuit **67**. A CPU **68** connects with a storage unit composed of a ROM **69** and a RAM **70**, in which a predetermined number of motor revolutions, timing of synchronization and the like have been stored. The CPU **68**, based on the signal obtained from each of the sensors S1, S2 and S3, controls all of the motors M1, M2 and M3 to have a certain number of revolutions as well as actuates the electric motor M1, M2 and M3 synchronously so that each of them are activated with a phase delayed as shown by a wave form in FIG. **17**.

As for a motion of the actuator "A", it is required that the separating vessel **4** is driven to form an elliptical motion "D" (see an arrow "D" in FIG. **2**) as viewed from the side thereof. On this purpose, a swash plate cam "C" or the like shown in FIG. **3** may be employed. That is, while the longitudinal shaft "B" as an input shaft side is in its rotating motion, "a roller" is slidably driven by the swash plate cam "C" axially attached to the longitudinal shaft "B" to bring the actuator "A" as an output shaft side into an elliptical motion.

FIG. **4** shows an embodiment of the drive means **6** to which a swash plate cam "C" is applied. This drive means **6** comprises; a motor **11** having a longitudinal motor shaft rotating as an input shaft side; a rotary shaft **13** axially attached to the motor shaft **10** and having a whirl-stop **12** arranged in an upper portion thereof; a cylindrical cam member **14** through which said rotary shaft **13** is inserted and to which the swash plate cam "C" is attached projecting outwardly therefrom with a certain inclination angle; a pair of rollers **15, 15**, which sidably move sandwiching the swash plate cam "C" at an upper and lower surfaces thereof; a support member **16** which moves up and down associated with the motion of said rollers **15, 15**; a cylindrical member **17** which is rotationally moved up and down by said support member **16** and said whirl-stop **12**; a second rotary shaft **18** arranged on an upper end of said cylindrical member **17** as offset from a center of axis of said rotary shaft **13**; and a joint piece **19** for coupling the second rotary shaft **18** to the separating vessel **4**. Reference numeral **20** designates a bearing arranged to allow the rotary shaft **13** to rotate within the cam member **14**, and reference numeral **21** designates another bearing arranged to allow the cylindrical member **17** to be rotationally moved up and down around the rotary shaft **13**. Further, reference numeral **22** designates an elongated hole disposed in the cylindrical member **17**, through which the whirl-stop **12** of the rotary shaft **13** is inserted.

An operation of a mechanism of the configuration explained above will be described. The drive means **6** in the present invention, as shown in FIG. **1**, is composed of three pieces of drive means in total, each of the drive means being disposed in each one of the sections which are defined by dividing the arc of peripheral edge portion **3** of the separating vessel **4** by three at every 120°. Each of the three drive means **6** is sequentially driven in a different cycle thus to rotationally shake the separating vessel **4** as a whole. FIG. **4** also shows "which location on the elliptical locus shown in FIG. **2**, each one of those three drive means is positioned in", wherein a phase is shifted at the point "A", point "B" and point "C" on the elliptical locus and the each one of three drive means **6** is respectively driven at each point to cause the separating vessel **4** to be rotationally shaken.

Then, when the motor **11** in FIG. **4** is rotated, the longitudinal motor shaft **10** is rotated followed by the rotation of the rotary shaft **13**. When the rotary shaft **13** is rotated, the cylindrical member **17** is rotated by the whirl-stop **12** attached to the upper portion of the rotary shaft **13**, and in turn the support member **16** fixedly attached to the cylindrical member **17** is also rotated. Then, when a pair of rollers **15, 15** attached to the lower end of the support member **16** sidably moves around the cam member **14** upwardly as sandwiching the swash plate cam "C" at the upper and lower surfaces thereof, the cylindrical member **17** is gradually moved upward with respect to the rotary shaft **13**. On the other hand, when the pair of rollers **15, 15** passes over the upper dead point to sidably move around the cam member **14** downwardly, the cylindrical member **17** is gradually moved down with respect to the rotary shaft **13**. The separating vessel **4** is connected to the cylindrical member 17 via the second rotary shaft 18 and the joint piece 19, so that a motion of the separating vessel 4 is not strictly limited but the separating vessel 4 is allowed to move freely to a certain extent.

The locus of the separating vessel 4 made by said drive means 6 inevitably becomes an elliptical locus when taking the motions in a horizontal direction and a vertical direction and also an inclined surface of the swash plate cam "C" into account, wherein a stroke in the horizontal direction defines a longitudinal axis of the ellipse and a stroke in the vertical direction defines a lateral axis of the ellipse. This means that the separating vessel is rotationally shaken at three locations in the peripheral edge portion thereof in order. That is, when one of the three drive means 6 disposed respectively in one of the three locations on the peripheral edge portion of the separating vessel is currently in point "A" on the elliptical locus, the other two of the drive means 6 disposed in the other locations are either in point "B" or point "C" respectively, thus to rotationally shake the separating vessel in sequence.

Since rice mixture composed of unhulled rice and unpolished rice supplied into the separating vessel 4 (see FIG. 1) has an acceleration getting greater toward the vicinity of the peripheral edge portion 3 and further the circular separating plate 5 is arranged as inclined upward toward the peripheral edge portion 3, the unpolished rice having smaller grain size and higher specific gravity is carried toward the peripheral edge portion to be discharged from the unpolished rice discharging port 9, while the unhulled rice having greater grain size and lower specific gravity slides down on the cone-shaped separating plate 5 to be discharged through the unhulled rice discharging port 8.

The configuration described above eliminates a failure in separation which otherwise possibly occurs on the same separating vessel 4, and makes it possible to maintain separating accuracy at a certain level as well as to provide an rotary shaking separator which requires no rotary shaft inserted through the central portion of the separating vessel 4.

FIG. 9 is a schematic longitudinal cross sectional view of another embodiment. FIG. 9 shows the embodiment in which a separating vessel 4 is supported from under side along a diagonal direction in side view by a drive means at a nose portion thereof to give an elliptical motion to the separating vessel 4. In the case where the separating vessel 4 is supported from under side along the diagonal direction, preferably the separating vessel 4 is supported by an eccentric shaft 50 via a crank plate 47 as shown in FIG. 10. Reference numeral 48 designates a rotary plate for connecting a motor shaft 49 with the eccentric shaft 50, and reference numeral 51 designates an eccentric shaft which is driven by the crank plate 47 to make an elliptical motion, said eccentric shaft 51 being fixedly attached to the separating vessel 4 via a fixing bracket 52. Reference numeral 53 designates a bearing which rotatably supports the eccentric shaft 51.

The crank plate 47 shown in FIGS. 9 and 10 has: an elongated hole 55 formed in a lower portion thereof, through which a supporting shaft 54 is inserted to make a supporting point of up and down motion; a bearing 56 disposed in an upper portion thereof for receiving the eccentric shaft 50; and the eccentric shaft 51 attached thereto at a middle portion thereof, which protrudes therefrom and makes an elliptical motion. As the motor shaft 49 of a gear motor 57 rotates, the elliptical plate 47 moves from a position indicated by a solid line to another position indicated by an alternate long and short dash line (see FIG. 10) thus to allow the separating vessel 4 to move elliptically in side view. As similar to the above description, the same effect may be obtained from the other two drive means, when a phase of the each eccentric shaft of these drive means is shifted by every 120°. The configuration described above eliminates a failure in separation which otherwise possibly occurs on the same separating vessel 4, and makes it possible to maintain separating accuracy at a certain level as well as to provide an rotary shaking separator which requires no rotary shaft inserted through the central portion of the separating vessel 4.

An alternative embodiment of the drive means 6 shown in FIG. 5, comprises four drive means in total, each one of the four drive means 6 being disposed in each one of four locations which are defined by dividing a peripheral edge portion 3 of a separating vessel 4 by four at every 90°. Each of the four drive means 6, as similar to that shown in FIG. 1, has one end fixedly attached to a machine frame and the other end served as an actuator "A" for supporting the separating vessel 4 to bring it into a rotationally shaking motion.

Although the embodiment of the drive means shown in FIG. 5 comprises four units of drive means 6 in total, an application is not limited to this but one motor shaft may be used to actuate all of four units of actuators "A". FIG. 6 is a schematic plane view illustrating an embodiment which employs one motor shaft to actuate all of four units of actuators "A", and FIG. 7 is a schematic side elevation view of FIG. 6 viewed from the motor shaft side.

In FIGS. 6 and 7, a square machine frame 23 has four support members 25 each being fixedly attached to an upper portion of each of four corner portions 24 thereof respectively for supporting the circular separating vessel 4, and a single motor 27 having a motor shaft 26 is fixedly mounted to a leg portion 28 of the machine frame 23. To explain the relationship between the circular separating vessel 4 and the four support members 25, a following description focuses on one of the support members 25. A rotary shaft 30 supported by a bearing 29 in the support member 25 and an eccentric shaft 31 offset from the center of said rotary shaft 30, are connected to each other by a rotary plate 32, wherein the eccentric shaft 31 extending from said rotary plate 32 is inserted through an eccentric bearing 33 fixedly attached to the separating vessel 4 so as to support and eccentrically shake the separating vessel 4. Further, each of the rotary shafts 30 is coupled with an intermediate shaft 36 via two universal joints 34 and 35 so as to transmit a revolution even when the rotary shaft 30 and the intermediate shaft 36 are not aligned but crossed.

A mechanism for transmitting an output from the single motor shaft 26 to the intermediate shafts 36 will now be described. Initially, the revolution from the motor shaft 26 is transmitted to an elongated central shaft 37 rotatably disposed laterally in a central portion of the machine frame 23, which allows two outputs to be taken out from one end side 37A and the other end side 37B respectively, and then each of these two outputs is transmitted to two intermediate shafts 36 respectively thus to transmit the revolution to four intermediate shafts 36 in total. A revolution is transmitted via a chain 40 from a sprocket 38 axially attached to the motor shaft 26 to another sprocket 39 axially attached to the central shaft 37, and then the revolution is transmitted via a chain 43 associated with an idle sprocket 42 from a sprocket 39A axially attached to the one end side of the central shaft 37 to two sprockets 41A, 41A axially attached to two intermediate shafts 36, 36 respectively. Similarly, the revolution is transmitted via a chain **45** associated with an idle sprocket **44** from a sprocket **39**B axially attached to the other side of the central shaft **37** to the other two sprockets **41**B, **41**B axially attached to the other two intermediate shafts **36**, **36**, respectively.

An operation of a mechanism of the configuration described above will now be described with reference to FIG. **8**. FIG. **8** is an enlarged view illustrating a connection between the support member and the separating vessel, wherein when the revolution from the motor shaft **26** is transmitted to the intermediate shaft **36** through a mechanism of the above configuration, the revolution is in turn transmitted through the universal joint **35** to the rotary shaft **30** in the support member **25**. Since the rotary shaft **30** is supported by the support member **25**, it can drive to rotate the rotary plate **32** at the center thereof without vibrating. On the other side of the rotary plate **32**, the eccentric shaft **31** is attached via a joint **46** so as to protrude at a position offset from the center of the rotary plate **32** so that a front end portion of the eccentric shaft **31** is inserted through the eccentric bearing **33** fixedly attached to the separating vessel **4** and thereby the separating vessel **4** may be rotationally shaken. The separating vessel **4** in FIG. **8** is eccentrically shaken from a position indicated by a solid line to another position indicated by an alternate long and short dash line, wherein a position in a lower dead point is at 36°, while a position in an upper dead point is at 45° and the displacement caused by the eccentric shake is 6°.

Although the effect is described with reference to one of the support member in FIG. **8**, the same effect is obtained from each one of the other three support members when the phase of the eccentric shaft is shifted by every 90°. The configuration as described above eliminates any failure in separation which otherwise possibly occurs on the same separating vessel **4**, and makes it possible to maintain separating accuracy at a certain level as well as to provide a rotary shaking separator which requires no rotary shaft inserted through the central ortion of the separating vessel **4**.

FIGS. **11** and **12** show a multi-row model of a rotary shaking separator which requires no rotary shaft inserted through the central portion of the separating vessels **4**, wherein referring to the schematic plan view of FIG. **11**, a peripheral edge portion **3** of each of the separating vessels **4** is supported at three locations, so that the separating vessel **4** is rotationally shaken by the drive means **6** disposed at said three locations. In this model, two separating vessels **4**A and **4**B are arranged opposite to each other, and material supply pipes **59**A, **59**B or means for supplying material to each of the two separating vessels **4**A, **4**B and unpolished rice discharging gutters **60**A, **60**B for discharging separated unpolished rice from each of the two separating vessels **4**A, **4**B are respectively disposed in the middle portion between those containers **4**A, **4**B.

FIG. **12** is a schematic longitudinal cross sectional view of the multi-row model. Referring to FIG. **12**, numbers of unpolished rice discharging gutters **60** are arranged in the middle portion between a ridge of the separating vessels **4**A and another ridge of the separating vessels **4**B to discharge the unpolished rice through an unpolished rice discharging cylinder **65** disposed in a central portion of a machine frame **64** to outside of the machine. A circular unhulled rice discharging portion **61** is formed in the central portion of each separating vessel **4**, and only the unhulled rice discharging portion **61** located at the lowest level is exclusively coupled with one end side of corresponding unhulled rice discharging gutter **62**A or **62**B, while the other end sides of the unhulled rice discharging gutters **62**A and **62**B are couples with a unhulled rice discharging cylinder **64** disposed in the center of the machine frame **63** to discharge the unhulled lice to outside of the machine.

In the configuration shown in FIG. **12**, two containers composed of the upper eparating vessel and the lower container are formed into one unit referred to as **4**A' or **4**B', and four sets of the unit **4**A' and another four sets of the unit **4**' are piled up with a unpolished rice discharging cylinder **65** introduced through the middle portion therebetween.

In the above configuration, when the drive means **6** is driven, each separating vessel **4** is rotationally shaken by the torque of the drive means. As a matter of course, multi-row model having the configuration described above can enhance a separating ability in comparison with a single-row case, while this configuration eliminates any failure in separation which otherwise possibly occurs on the same separating vessel **4**, and makes it possible to retain a certain level of separating accuracy as well as to provide an rotary shaking separator which requires no rotary shaft inserted through the central portion of the separating vessel **4**.

A regulator unit for regulating an inclination angle of a plurality of separating plates within each of the separating vessels **4** will now be described. As obviously seen from FIGS. **18** and **20**, the segmental separating plates **72** are arranged in a cone-shaped form inside the separating vessel **4**. The adjacent separating plates **72**, **72** overlap one over another at side edges thereof. A regulator unit **73** for regulating an inclination angle of the separating plates **72** is disposed beneath the separating plate **72** within the separating vessel **4**. Said regulator unit **73** comprises: a cylindrical cam **76** attached to a bottom portion **74** of the separating vessel and having a plurality of oblique cam slots **75**; a rotary drive unit **78** for rotating said cylindrical cam **76**, which includes a reversible motor **77**; and a support frames **83** having in one end a pin **79** engaged with the cam slot **75** of the cylindrical cam **76**, having the other end rotatably coupled via a pin **82** to a bracket **81** fixedly attached to a side-wall **80** of the separating vessel **4**, and supporting the segmental separating plate **4** from under side. As can be seen most obviously in FIG. **20**, the rotary drive unit **78** includes a pinion **84** arranged on an output shaft of the reversible motor **77** and a sector-shaped rack **85** attached to the cylindrical cam **76** and engaged with the pinion **84**, wherein the revolution of the motor causes the pin **79** to be moved along the oblique cam slot **75**, which in turn swings each separating plate **72** around the rotational coupling pin **82**, and thereby a slope of the separating plate **72** may be regulated to a desired angle, for example, from 8° to 12°.

Then, the circular dam arranged on the separating plates to form the unhulled rice discharging portion will be described. Referring to FIGS. **21** and **22**, a relationship between the separating plates **72** of the separating vessel **4** and the circular dam **86** are shown in detail. The circular dam **86** is mounted on the separating plates **72**, and a plurality of springs **87** is disposed between the circular dam **86** and the separating plates **72** for coupling them. Thus, the dam **86** is moved up or down in response to the regulated inclination angle of the separating plates **72**, thereby preventing a gap from being created between the separating plates **72** and the dam **86**. The circular dam **86** has an opening of unhulled rice discharging port **88** and a shutter for opening or closing said unhulled rice discharging port **88** is rotatably attached to the dam **86** with a shaft **90**. A solenoid **91** served as an actuator is fixedly mounted to the machine frame and is connected to the shutter **89** via a cable **92** to open or close the shutter **89** by the operation of the solenoid **91**. Although the explanation focuses on a solenoid to be used for an actuator, it should be easily recognized that an air cylinder might be used.

A unhulled rice/unpolished rice detection sensor will now be described with reference to FIG. **23**. Above the segmental separating plate **72** of the separating vessel **4** is provided a unhulled rice/unpolished rice detection sensor **93**, which radiates light against the unhulled rice and unpolished rice on the separating plate **72** and receives reflected light to determine whether they are unhulled rice or unpolished rice based on a difference in amount of the reflected light. Thus, the unhulled lice/unpolished rice detection sensor **93** determines a boundary between unhulled rice area and unpolished rice area. The unhulled rice/unpolished rice detection sensor **93** is preferably located on the line extending from the unhulled rice discharging port **88** of the dam **86** radially toward the side-wall of the separating vessel and as well on the boundary between the unhulled rice area and the unpolished rice area somehow closer to the center of the container.

Immediate after the beginning of separating operation, when the thickness of rice mixture are getting steady as time goes by, the boundary between the unhulled rice area and the unpolished rice area would be obviously created as shown by reference Al in FIG. **23**. At that time, as the unhulled rice/unpolished rice detection sensor **93** determines that the unhulled rice layer exists and sends an ON-signal, the solenoid **91** responsive to the signal is biased through a timer (not shown) set to a certain time period, for example, within the range of 0.5 to 1.5 second to open the shutter **89**. Thereby, the unhulled rice are discharged rapidly from the unhulled rice discharging port **88** and the boundary between the unhulled rice area and the unpolished rice area moves to be formed gradually into concave shape as sequentially indicated by the references **A1**, **A2** and **A3**. After that, when the timer is turned off and the solenoid **91** is released, the shutter **89** closes the unhulled rice discharging port. Then again, a width of the unhulled rice layer increases and the boundary returns from the level indicated by reference **A3** through the reference **A2** back to the reference **A1** in a few seconds. The unhulled rice/unpolished rice detection sensor **93** again detects the unhulled rice layer, and the solenoid **91** is biased to open the shutter **89** for a predetermined period. Thus, when the region of unhulled rice layer moves up to a specified location, the unhulled rice which have been dammed are discharged, and when the region of unhulled rice layer retracts away from a specified level, the discharge of the unhulled rice is stopped. Accordingly, for the period from the beginning of separation throughout the separating operation, an amount of unhulled rice to be discharged is controlled based on the ratio of the unhulled rice layer to the unpolished rice layer on the cone-shaped separating plate. It is of course contemplated that the solenoid may be biased by turning on the manual switch (not shown) to open the shutter and discharge the unhulled lice from the discharging port **88**.

In the operation of separating the unhulled rice and the unpolished rice in the rice mixture from each other, if physical properties, such as water contents, friction coefficient or the likes of the rice mixture remain as constant, the separating ability would not be changed, but in the case of separating the unhulled rice and the unpolished rice in the rice mixture from each other having different physical properties (such as water contents or friction coefficient), the thickness of layer of the rice mixture on the separating plates would be varied and eventually the separating ability would also be influenced. According to the present invention, the amount of supplied rice mixture and the number of revolutions of the separating vessel are kept in predetermined values, while the inclination angle or the slope of the separating plate of a separating vessel can be regulated in response to the variation in thickness of the layer, thereby allowing to retain the thickness of the layer in an appropriate level.

Referring to FIG. **23**, a level sensor **94** is further provided for detecting a thickness of the layer of rice mixture on the segmental separating plate **72**. The level sensor **94** and said unhulled rice/unpolished rice detecting sensor **93**, as shown most obviously in FIG. **18**, are mounted to a link mechanism **95** arranged in parallel with the separating plate **72**. As for the level sensor **95**, a photoelectric switch of distance setting type (available as model No. ES3-CL from Omron Corp., Japan) or an analog output photoelectric sensor may be employer therefor.

FIG. **24** shows an operation of a photoelectric switch **94** of distance setting type in detecting a thickness of a layer. This photoelectric switch of distance setting type comprises: a projecting portion **96** for irradiating parallel rays toward a detecting region; a light receiving lens **97** for condensing reflected light from an object to be detected; a half-split light receiving element **98** arranged behind said light receiving lens **97** and composed of a photodiode N for proximal side of light receiving and another photodiode F for distal side of light receiving; and a case **99** containing above elements therein. The level sensor **94** monitors a position of the rice mixture on the separating plate **72** comparing with a setting distance from the upper limit position "**L0**" of the rice mixture (for example, a distance from the separating plate **72** is 15 mm) to the photodiode N, and also comparing with a setting distance from the lower limit position "**L1**" of the rice mixture (for example a distance from the separating plate **72** is 10 mm) to the photodiode F Thus, an appropriate level in thickness of the rice mixture falls in the range between **L0** and **L1**. Thereby, the operation of the reversible motor **77** can be controlled by switching on/off operation of the photodiodes N or F.

When the layer thickness of the rice mixture reaches to L1 level from the separating plate **72** immediate after the beginning of separating operation, both of the photodiodes F and N are off and a normal rotation circuit is actuated to rotationally drive the reversible motor **77** in the normal direction so that the inclination angle of the separating plate **72** may be increased to be steep. When the layer thickness increases from L1 level to **L0** level, the photodiode F is switched on and the photodiode N is switched off, so that the normal rotation circuit can not be actuated to stop the reversible motor **77**. When the layer thickness exceeds **L0** level, both of the photodiodes F and N are on and thereby a reverse rotation circuit is actuated to rotationally drive the reversible motor **77** in the reverse direction so that the inclination angle of the separating plate **72** may be decreased to be gentle.

FIG. **25** shows an operation of an analog output photoelectric sensor in detecting a thickness of a layer. The analog output photoelectric sensor comprises: a projecting portion **96** for irradiating parallel rays toward a detecting region; a light receiving lens **97** for condensing reflected light from an object to be detected; a light receiving element **98'** arranged behind said light receiving lens **97**; and a case **99** containing above elements therein; wherein outputs from the light receiving element **98'** at the upper and the lower limit levels are set as upper and lower thresholds respectively, and if the output from the light receiving element is within the range between the thresholds, then the angle of the separating plate **72** is determined to be appropriate and the reversible motor **77** is not driven, while if the output is over the upper threshold or under the lower threshold, the reversible motor

77 is rotationally driven to decrease or increase the inclination angle of the separating plate **72**.

As having been described above, since the level sensor is located in rather proximal side to the center of the separating plate **72** and detects the layer thickness at that region to regulate the inclination angle of the separating plate **72**, the rice mixture is distributed over the separating plate **72** with the layer thickness being thicker in central side gradually getting thinner toward the peripheral side (see FIG. **26**), so that such risk can be reduced that the unhulled rice might be discharged from the unpolished rice discharging port by the centrifugal force.

AVAILABILITY TO INDUSTRIAL USE

As having been described above, since the present invention provide a rotary shaking separator comprising; a separating vessel having a plurality of segmental separating plates arranged in the cone-shaped form; and a drive means for rotationally shaking said separating vessel, so that once material to be separated, that is mixture composed of unhulled rice and unpolished rice, is supplied into a predetermined location of said separating vessel, the components of said mixture are discharged respectively in such a way that said unhulled rice are discharged from a peripheral edge of said separating vessel and said unpolished rice from a central bottom portion of said separating vessel; wherein said separating vessel is supported at peripheral edge portions by a plurality of drive means arranged in said peripheral edge portions on the same radii from the center of said separating vessel with arc lengths thereof being equal to one another so that said peripheral edge portions of said separating vessel may be sequentially driven elliptically by said plurality of drive means to rotationally shake the whole of said separating vessel, and as a result, the present invention has made it possible to retain a constant level of separating accuracy without any failure in separation which might otherwise occur on the same separating plate, and further to provide a rotary shaking separator which requires no rotary shaft inserted through the central portion of the separating vessel, thereby eliminating such defects that mounting is difficult, maintenance is troublesome, or discharging of unhulled iice is not facilitated.

Further, even in the case where a plurality of said circular sets of separating plates are arranged in multi-row, since all units of the separating plates can be driven with a synchronous and steady rotational shaking motion as a whole, a failure in separation cannot occur on the same separation frame, thereby enhancing a separating ability proportional to the number of rows.

What is claimed is:

1. A rotary shaking separator comprising:

a separating vessel having a plurality of segmental separating plates arranged in a cone-shaped form; and

a drive means for rotationally shaking said separating vessel, so that once mixture composed of unhulled rice and unpolished rice is supplied into a predetermined position of said separating vessel, the components of said mixture are discharged respectively in such a way that said unhulled rice is discharged from a peripheral edge of said separating vessel and said unpolished rice from a central bottom portion of said separating vessel;

wherein said drive means includes a plurality of drives;

wherein said separating vessel is supported by said plurality of drives which are arranged in peripheral edge portions on the same radii from the center of said separating vessel with arc lengths thereof being equal to one another; and

said peripheral edge portions of said separating vessel are sequentially driven elliptically by said plurality of drives so that the whole of said separating vessel is shaken rotationally.

2. A rotary shaking separator in accordance with claim **1**, in which a plurality of electric motors are provided corresponding to said plurality of drives as one-by-one.

3. A rotary shaking separator in accordance with claim **2**, further comprising:

a measuring unit for measuring a number of revolutions of a drive shaft of each of said electric motors when said plurality of electric motors is operated synchronously; and

a controller for controlling every electric motor to have a predetermined number of revolutions based on an output from said measuring unit as well as for synchronously operate each one of said plurality of electric motors with a predetermined phase delay therebetween.

4. A rotary shaking separator in accordance with claim **1**, in which a single electric motor is used to actuate said plurality of drives.

5. A rotary shaking separator in accordance with claim **4**, said drive means comprises:

an input shaft rotatably arranged laterally so as to transmit a revolution from said electric motor;

an intermediate shaft connected to said input shaft via a universal joint; and

an eccentric shaft axially attached to said intermediate shaft;

wherein said peripheral edge portion of said separating vessel is laterally supported by said eccentric shaft to give an elliptical motion to said peripheral edge portion.

6. A rotary shaking separator in accordance with either of claim **2** or **3**, in which each of said plurality of drives comprises:

an input shaft rotatably arranged vertically so as to transmit a revolution from said electric motor;

a swash plate cam axially attached to said input shaft; and

an output shaft which follows displacement caused by a revolution of said swash plate cam to make an elliptical locus;

wherein said peripheral edge portion of said separating vessel is supported from under side by said output shaft to give an elliptical motion to said peripheral edge portion.

7. A rotary shaking separator in accordance with either of claim **2** or **3**, in which each of said plurality of drives comprises:

an input shaft rotatably arranged vertically so as to transmit a revolution from said electric motor;

a cam member through which said input shaft is inserted and to which a swash plate cam is axially attached; and

an output shaft which is slidably moved on said swash plate cam by the revolution of said input shaft and makes an elliptical locus by displacement rotationally moving up and down;

wherein, said peripheral edge portion of said separating vessel is supported from under side by said output shaft to give an elliptical motion to said peripheral edge portion.

8. A rotary shaking separator in accordance with either of claim **2** or **3**, in which each of said plurality of drives comprises:

an input shaft rotatably arranged obliquely so as to transmit a revolution from said electric motor;

an eccentric shaft axially attached to said input shaft;

a crank plate for converting a true circular motion of said eccentric shaft to an elliptical motion; and

an output shaft axially attached to said crank plate to make an elliptical locus;

wherein, said peripheral edge portion of said separating vessel is obliquely supported from under side by said output shaft to give an elliptical motion to said peripheral edge portion.

9. A rotary shaking separator in accordance with claim **1** in which a plurality of said separating vessels are arranged in a multi-row configuration.

10. A rotary shaking separator in accordance with claim **9**, further comprising:

a circular dam disposed on said separating plates in a center of each of said separating vessels and having a unhulled rice discharging port;

a shutter for opening or closing said unhulled rice discharging port; and

a unit for actuating said shutter;

wherein said unit for actuating said shutter is actuated in response to an output signal from a unhulled rice/unpolished rice detection sensor for distinguishing unhulled rice and unpolished rice in rice mixture from each other on the separating plates.

11. A rotary shaking separator in accordance with claim **10**, in which each of said separating plates of each of said separating vessels is constructed such that an inclination angle thereof is allowed to be regulated respectively, and said separator further comprises a regulator unit for regulating the inclination angle of said separating plate.

12. A rotary shaking separator in accordance with claim **11**, further comprising a level sensor for detecting a layer thickness of the rice mixture on said separating plates, wherein when said level sensor detects a level in thickness of said rice mixture being over or under predetermined levels, said regulator unit is actuated to set the inclination angle of said separating plate toward a gentle angle direction or toward a steep angle direction.

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